DYNAMIC TESTING OF THE VIADUCS DU CHENE

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Mandat de recherche no 8/80 "Comportement dynamique des ponts-routes sous l'action du trafic lourd" de la Commission de recherches en matière de construction des routes du Département fédéral de l'intérieur

Rapport d'essais

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1 INTRODUCTION

The Viaducs du Chêne (FIGURE 1) are twin, two lane, 12 span continuous composite bridges on the N1 motorway between Lausanne and Yverdon near the village of Chavornay. Between their construction in 1978 and opening to traffic in November 1982 they have been the subject of a series of static and dynamic tests [1] [2] [3] [4] [5] [6].

The tests reported here were aimed at examining the dynamic behaviour of the bridge, normally carrying traffic from Yverdon to Lausanne. Of particular interest was the impact effect from vehicles running on the bridge and crossing the expansion joint at the Yverdon abutment. Two common types of truck of significantly different weight and axle configuration were used independently.

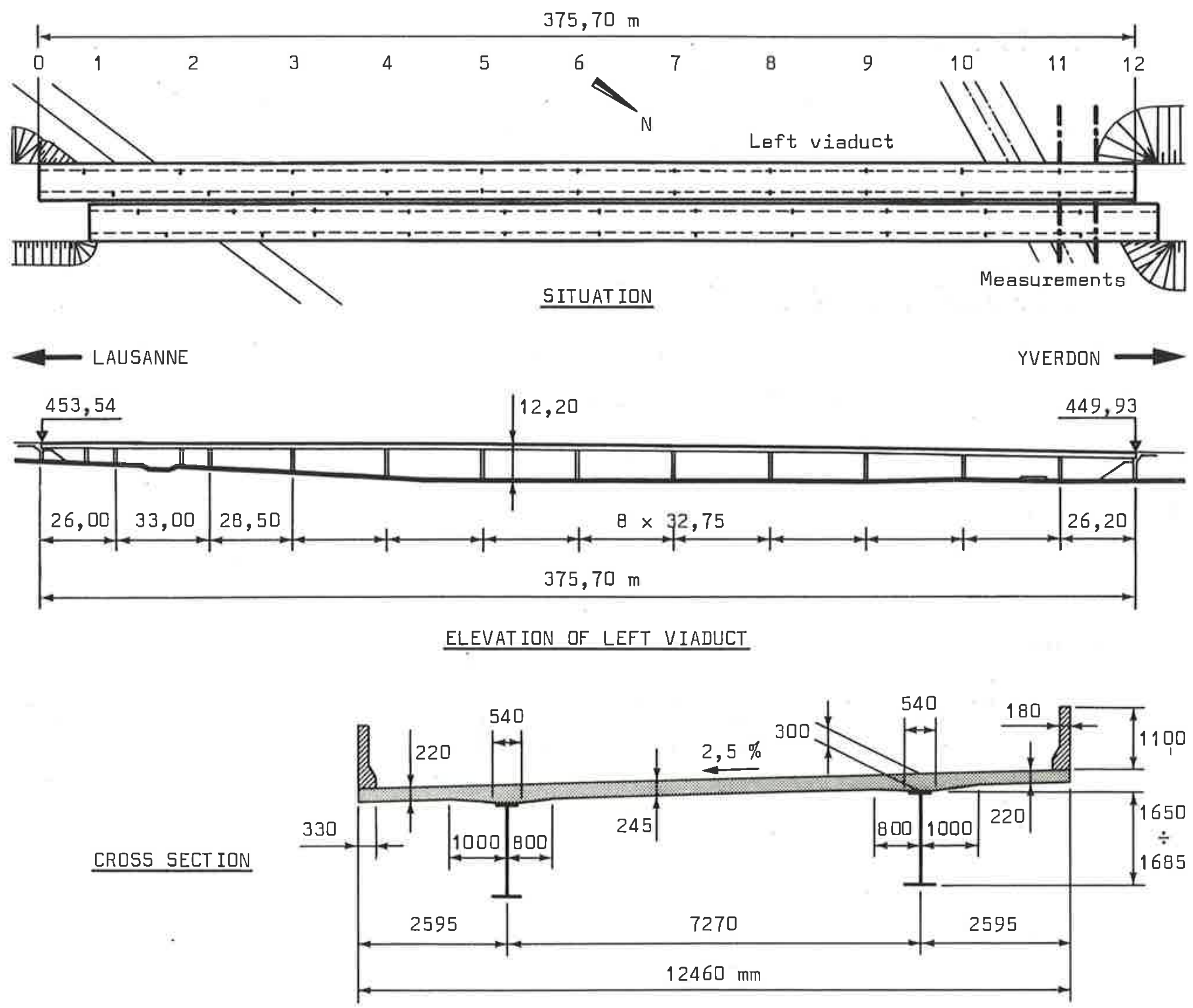


FIGURE 1

The Viaducs du Chêne.

To simulate a severe disturbance in the road surface the tests were repeated with each vehicle having to drive over a 300 x 50 mm scaffold plank placed transversely in the middle of the Yverdon end span.

The tests were carried out in the general framework of a programme of dynamic testing undertaken with EMPA.

2 DESCRIPTION OF THE TESTS

2.1 THE TEST TRUCKS

Two vehicles were used as shown in FIGURE 2. On Friday 15 October a twin axle 16 t FBW belonging to EMPA was loaded with concrete weights to create a gross weight of 16,25 t. On Monday 18 October a 3 axle 25 t Saurer, from a local firm, was loaded with sand to produce a gross weight of 24,91 t. The tyre pressures of the 16 t FBW were 8 bar and the 25 t Saurer 6 bar.

2.2 SPEED CONTROL

A trailing fifth wheel device supplied by EMPA was fitted behind both vehicles in turn. This gave accurate speed indication in the drivers cab on an independent speedometer. The wheel was raised and lowered hydraulically by remote control from the drivers cab to avoid damage when the vehicle was crossing a plank.

2.3 LINES, DIRECTIONS AND SPEEDS OF PASSAGE

The drivers were asked to drive in both directions along two lines :

- the centre of the bridge (symmetric centre),
- as close as possible to the north east parapet.

The centre-line was measured and marked with chalk. No attempt was made to mark a line at the

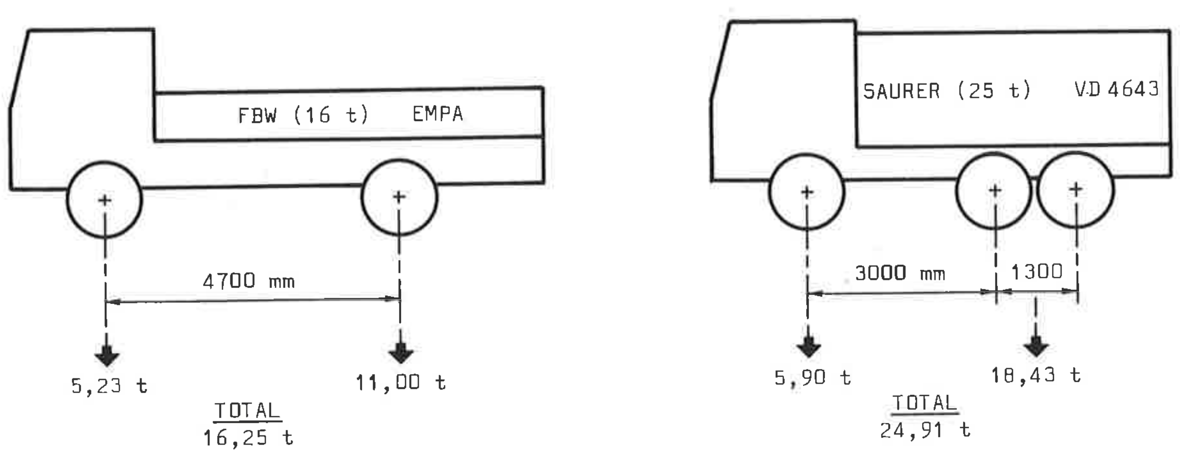


FIGURE 2

Details of trucks.

parapet as it was accepted that the driver would be more influenced by the proximity of the parapet in his judgement. It was noticed that the EMPA driver tended to align his nearside wheels with the carriageway marking which was 1,2 m from the wall. Despite the low priority placed on marking the lines it was observed that both drivers were constant in their passes.

With regards to directions and speeds both vehicles travelled both lines in both directions (Lausanne to Yverdon and Yverdon to Lausanne) except the 25 t Saurer in the direction Yverdon to Lausanne with the plank in the roadway. See the synopsis of TABLE 1.

The maximum speed of the 16 t FBW was 60 km/h and passes were made at either 5 or 10 km/h increments. The maximum speed achieved by the 25 t Saurer in the uphill (Yverdon to Lausanne) direction was 80 km/h. In the down hill direction its highest speed was 100 km/h.

DIRECTION	LINE	PLANK	TRUCK	MAX. SPEED [km/h]	INCREMENT [km/h]	REMARKS
LAUSANNE ↓ YVERDON	CENTRE	+	16 t 25 t	60 85	10 5	
		-	16 t 25 t	60 100	10 10	
	PARAPET	+	16 t 25 t	60 60	5 5	
		-	16 t 25 t	60 80	5 10	No 5 km/h
YVERDON ↓ LAUSANNE	CENTRE	+	16 t 25 t	60 —	10 —	
		-	16 t 25 t	60 80	10 10	
	PARAPET	+	16 t 25 t	60 —	5 —	
		-	16 t 25 t	60 80	5 10	No 5 km/h

TABLE 1

Synopsis of test passes.

2.4 ARTIFICIAL IMPACT FROM A PLANK IN THE ROADWAY

A 300 x 50 mm scaffold plank 4,5 m long was placed across the roadway at midspan (span 11 - 12) and the tests repeated, except as noted for the 25 t Saurer, so that the bridge would be exited by a more positively forced response than ordinary deck irregularities.

2.5 STATIC (CRAWL SPEED) PASSES

Both trucks made crawl speed (< 5 km/h) passes on both lines and directions before and after each group of tests. The "static" influence lines recorded for each gauge served as a basis for the assesment of dynamic effects and a "calibration" of the tests as a whole with isolated deflection measurements made with a seperate "static deflection measurement" system used on October 14th, and measurements made in 1978 (see TABLE 2).

POSITIONS	DEFLECTIONS [mm] AT GAUGE 162			RIGIDITY OF BRIDGE [kN/mm]
	SAURER (25 t) [6]	SAURER (25 t)	FBW (16 t)	
A	2,45	2,32	1,52	108 (SAURER) 105 (FBW)
B	0,01			
C	- 0,73			
D	- 1,01			
E	0,36			
F	3,45	3,21	2,04	

TABLE 2

Comparison of deflections measured at gauge 162 for positions A to F and rigidity of bridge.

3 EQUIPMENT AND MEASUREMENTS

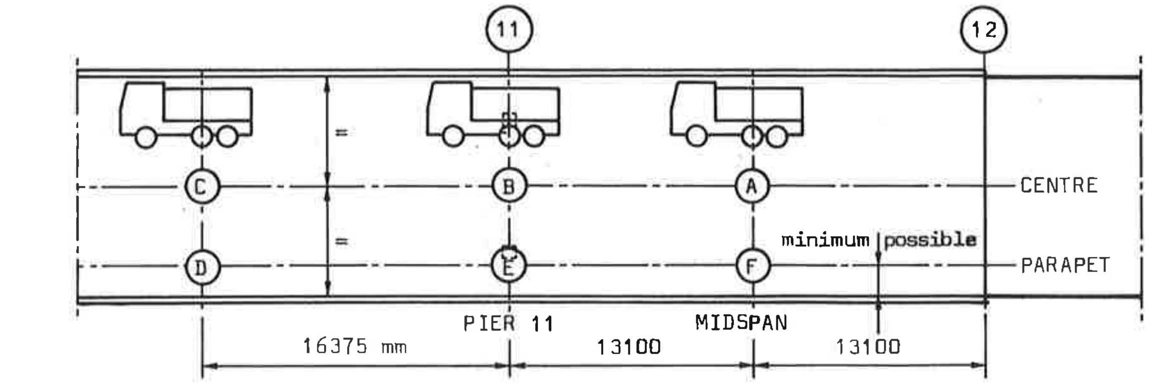
The dynamic response of the bridge was measured at two points (FIGURE 3 a), the middle of the Yverdon end span and over the first pier bearing of that span. Response in the longitudinal direction was measured at midspan by :

- a W 20 inductive gauge (162) fixed between the ground and underside of the girder for vertical deflection,
- a PL 10 strain gauge (150) glued at the centre of the underside of the girder lower flange.

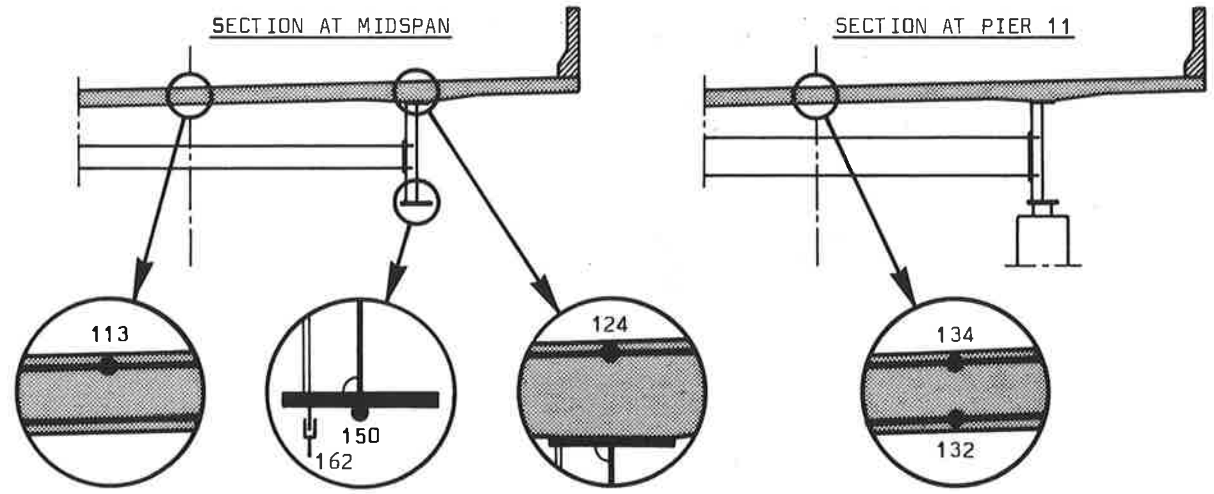
Response in the transverse direction in the slab was measured with PL 10 gauges which had been fixed to the transverse reinforcing bars before concreting. They had all been used before and are numbered and located on FIGURE 3 b.

The signals from all these gauges were continuously processed and recorded by the system shown in FIGURE 4 whose principal elements are :

- a 6 channel Hottinger Baldwin 6A-5 measuring bridge,
- a 12 channel Bell and Howell CRP 4010 reel to reel tape recorder,
- a 6 channel Schlumberger OM 4501 ultra-violet-on-paper trace recorder.



a) Static load measurements.



b) Gauges.

FIGURE 3

Position of static load measurements and of gauges.

Except for lunch breaks the signals were monitored and recorded continuously on the Bell & Howell recorder running at 15/16 in./sec. The U.V. paper trace was only activated for the actual passage of the vehicles and reproduced the recorded signal from the Bell & Howell to assure recording quality. Only two gauges were reproduced at this time, 162 and 150.

3.1 CALIBRATION OF THE GAUGES AND CABLE LOSSES

The calibration of the W 20 inductive gauge (162) and losses due to the coaxial cable connecting the other gauges were established later in the laboratory. The W 20 inductive gauge was checked in a micrometer over its full range and it was found that the losses were negligible. The coaxial cables used with the strain gauges were marked and checked using a HBM K 3602 calibration unit. It was found that the signals from gauges connected with 100 m lengths had to be increased by 19 % (x 1,19) and those with 25 m cables by 5 %.

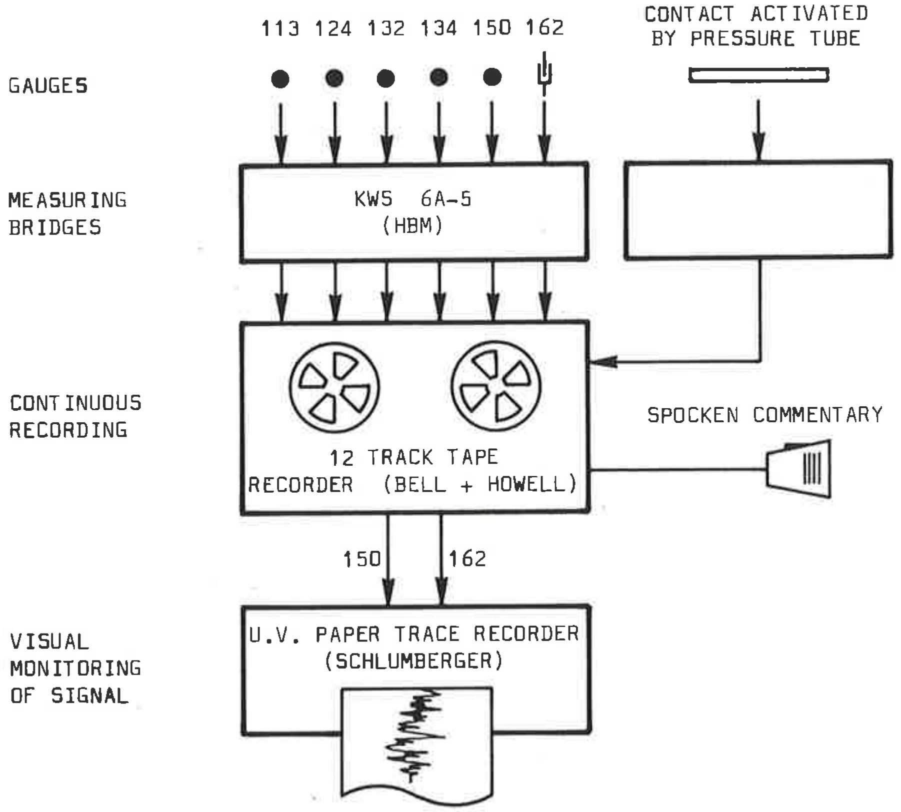


FIGURE 4

Recording system.

3.2 INDICATION OF VEHICLE POSITION

Although it is possible to estimate the vehicle's position in the test span from inspection of the influence lines, it is advantageous to have a more punctual reference. The afternoon tests of 18 October with the 25 t Saurer were carried out with recordings of the vehicle's position provided by the following system :

- two, pneumatic tube, vehicle counting instruments were set up with one tube accross the roadway just off the bridge on the Yverdon abutment and the second tube 30 metres down the bridge towards Lausanne,
- the pneumatic diaphragm switches were wired in parallel to a spare KWS 6A-5 unit and the resulting pulses from the closing of either switch by the passage of the vehicle were recorded on the tape recorder.

4 THE RESULTS

4.1 TREATMENT OF THE RECORDINGS

The signals recorded on magnetic tape were visualised by reproduction on the Schlumberger U.V. paper traces and all values scaled-off "manually". On reproduction it was found that the signals

from the longitudinal gauges, 162 and 150, were occasionally disturbed by background interference but were easily measured with confidence in their accuracy. This was not, however, true for the gauges on the transverse reinforcing bars. All signals were heavily confused with background noise and although the magnitude of the mean values could be estimated it was impossible to asses any dynamic effect with confidence. As a result an electronic filter was constructed which permitted filtration from 1 to 12 and 10 to 120 hertz. Some time was spent "calibrating" the effects of this unit at various frequencies, both with the poor recordings from the transverse bar gauges and reliable longitudinal recordings already translated. Particular attention was paid to the efficiency of the chosen cut-off frequency and any tendancy to change the amplitude of the signal. On this latter point no appreciable change was found.

The question of a suitable filter frequency to work with was resolved by replaying one of the most sensitive gauge signals, recorded for impact with the plank, and successively reducing the filter frequency. The various traces were compared to see the effect both on the signal and background noise. A satisfactory compromise was found at 5 to 6 hertz with the forced transverse frequency being around 3,5 hertz and of very short life. Nevertheless there were still some recordings where the noise remained relatively so great that it was not felt possible to give confident values of dynamic effects. In these cases only the static values have been given although it should be noted that the dynamic effects were not decipherable either because they were relatively small (< 10 %) or involved minor stress changes ($\ll 0{,}5$ N/mm^2) in the bar.

It is indeed most important, before considering the results, that the magnitudes of the measured stress and deflection changes are kept in perspective. That is to say that 10 μ changes from static deflections of 2,6 mm seem relatively important but are still $2{,}6 \bullet 10^{-6}$ of the span.

4.2 PRESENTATION OF THE RESULTS

All maximum values of stress and deflection were scaled from the paper trace recordings and converted into N/mm^2 and mm by comparison with the internal calibration values of the measuring bridges which were periodically added to the recordings during the tests. The resulting values appropriately multiplied by gauge factors and correction factors for the coaxial cables are presented in tabulated form in the APPENDIX.

4.3 THE DYNAMIC IMPACT FACTOR

The tables include a value of the dynamic impact factor ψ calculated for each gauge for every passage. There are several methods of calculating this factor to express the most common and simple method has been adopted and is as shown schematically in FIGURE 5.

The maximum excess vibrational stress or deflection in the span, whether coincident with the maximum of the median line or not, is divided by the maximum static (crawl speed) value. Thus a ψ value of 100 % means that the static value has been doubled by the vibrational response of the bridge.

This definition has been adopted to enable direct comparison with other reports and conventionally accepts the static, crawl speed, value as a mean reference value. The justification and inconvenience of this convention are briefly discussed in the following section.

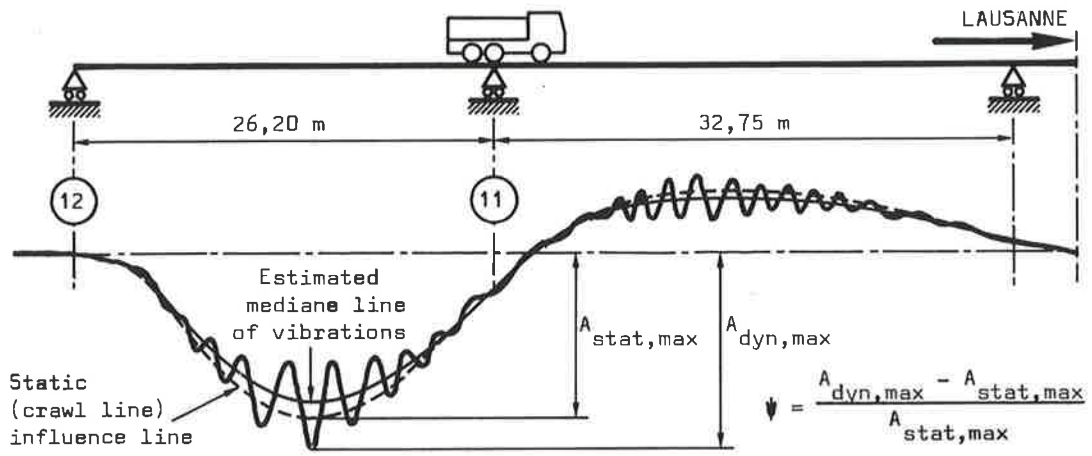


FIGURE 5

Definition of the dynamic impact factor ψ.

5 DISCUSSION OF THE RESULTS

5.1 LONGITUDINAL BEHAVIOUR

a) THE RIGIDITY OF THE BRIDGE

From the tabulated values of static deflections in the APPENDIX the longitudinal rigidity of the bridge in kN per mm of deflection was found to be :

- for the 25 t Saurer : 108 kN/mm,
- for the 16 t FBW : 105 kN/mm.

b) THE DYNAMIC BEHAVIOUR

From inspection of the tabulated results of gauges 162 and 150 and the summary of maximum impact values (TABLE 3), the following basic remarks can be made :

- ψ values from deflection (162) are invariably greater than the corresponding stress value (150),
- the maximum ψ value is 113 % with the plank (FBW) and 16 % without (Saurer),
- the disturbing effect expected from the vehicle passing the expansion joint, direction Yverdon to Lausanne is not as great as the vibration produced by the vehicle running steadily down the bridge, Lausanne to Yverdon,
- the vibration is more pronounced when the vehicles are running close to the parapet,
- without the plank there is a peak in the ψ against speed curve around 15 km/h,
- with the plank both vehicles produce the maximum impact around 10 km/h.

LINE	PLANK	YVERDON to LAUSANNE						LAUSANNE to YVERDON					
		SAURER (25 t)			FBW (16 t)			SAURER (25 t)			FBW (16 t)		
		ψ_{max} [%]		speed [km/h]	ψ_{max} [%]		speed [km/h]	ψ_{max} [%]		speed [km/h]	ψ_{max} [%]		speed [km/h]
		defl.	stress		defl.	stress		defl.	stress		defl.	stress	
CENTRE	+	—	—	—	101	102	10	90	65	10	113	102	10
	-	9	7	50	3	3	30	16	15	70	9 *)	7 *)	60 *)
PARAPET	+	—	—	—	100 102	79 75	10 15	96	89	15	108	84	10
	-	8	3	50	5 10	5 3	10 45	13	12	60	6 11	7 5	15 55

*) Upwards trend but 60 max. speed

TABLE 3

Summary of maximum longitudinal impact factors ψ_{max}.

5.2 TRANSVERSE BEHAVIOUR

All gauges on the transverse reinforcing bars required high amplification (measuring range of 200 µm/m) on the KWS bridges. This in turn amplified the background noise and interference which lead to the use of a filter for preparing the paper trace recordings. Despite the use of a filter there were several traces which could not be confidently deciphered and the results presented for the transverse bars should be considered as reflecting orders of magnitude and general trends rather than precise discrete values in each case.

On inspection of the traces it was found that when the vehicles were running on the centre of the bridge the maximum stresses occurred with the heavy axles of the vehicles directly over the line of the bars themselves and these are the values presented in the tables of the APPENDIX. However, as has been previously shown for the static transverse load distribution [1], the "non-structural" concrete parapet has a very significant effect on the bridge behaviour and this is very apparent for vehicles running by the side of the parapet. In the case of gauges 124 and 132 both vehicles produced stress changes in the opposite sense to those produced when travelling down the centre line (FIGURE 6). This effect is denoted in the results tables by the convention that a change in the compression sense is negative.

All results presented in the tables are values measured at the same points as for running on the centre line. However these may not be the maximum stress changes produced during the passage of a vehicle as may be seen for gauge 132 in FIGURE 7. It was also noticed, when the plank was introduced, that gauge 132 showed considerable dynamic effects even though 13 m from the plank. Although these could not be presented in the results tables as they are not amplifications of the stress referred to there, it was felt worthwhile estimating and presenting them seperately on the basis of percentages of the particular median stress. The resulting impact values ψ, calculated on the basis of the model presented in FIGURE 7 are given in TABLE 4. As may be seen there is a considerable response to the impact although the stress changes are still relatively small (± 1 N/mm^2).

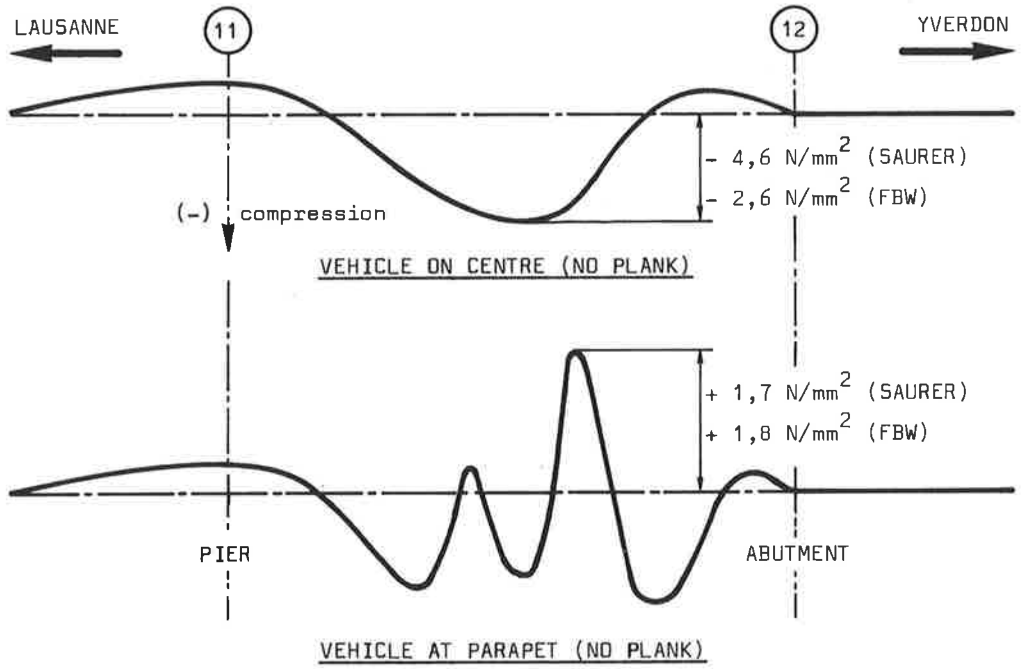
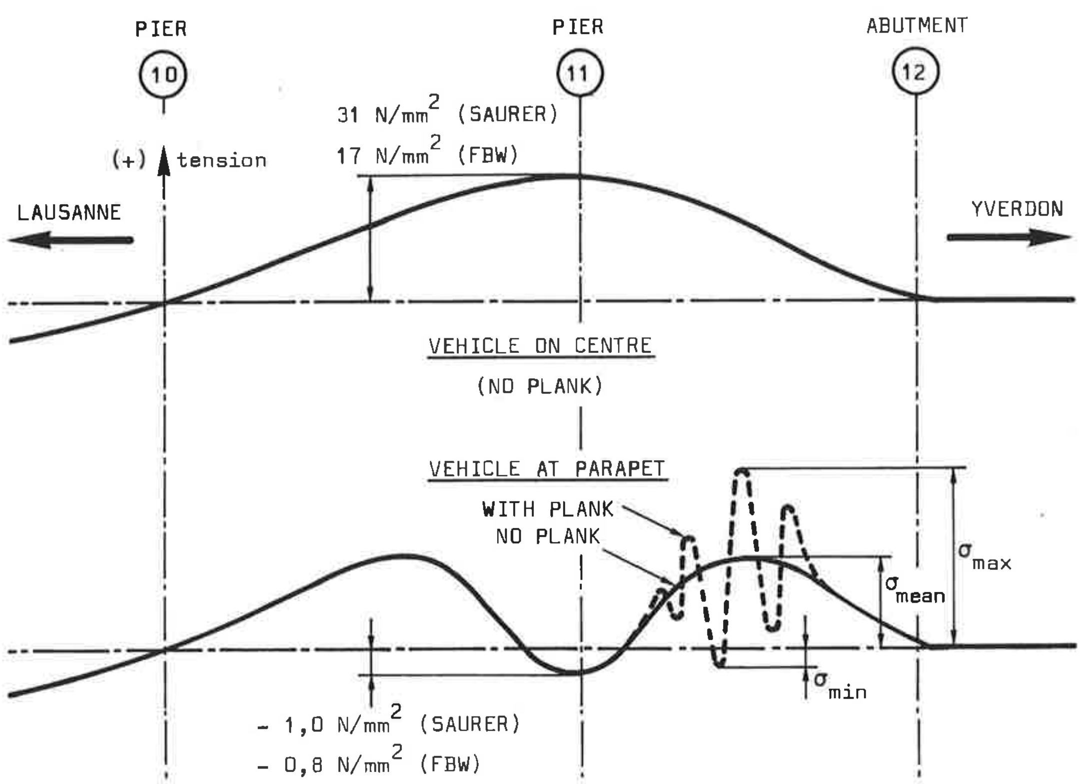


FIGURE 6

Typical stress traces for gauge 124 with static (crawl speed) stresses.



Local dynamic effects (see TABLE 4) : $+ \psi = \dfrac{\sigma_{max} - \sigma_{mean}}{\sigma_{mean}}$; $- \psi = - \dfrac{\sigma_{mean} - \sigma_{min}}{\sigma_{mean}}$

FIGURE 7

Typical traces from gauge 132 and explanation of derivation of local ψ values.

SPEED [km/h]	FBW (16 t)			SAURER (25 t)		
	σ_{mean} [N/mm^2]	+ ψ [%]	- ψ [%]	σ_{mean} [N/mm^2]	+ ψ [%]	- ψ [%]
5 L-Y	—	—	—	0,8	40	- 20
10 Y-L	0,4	30	- 67	—	—	—
10 L-Y	0	0	0	1,2	33	- 47
15 Y-L	0,4	130	- 200	—	—	—
15 L-Y	0,3	150	- 100	1,3	25	- 81
20 Y-L	0,4	66	- 67	—	—	—
20 L-Y	—	—	—	1,4	44	- 100
25 Y-L	0,3	0	0	—	—	—
25 L-Y	0,3	0	0	1,1	43	- 93
30 Y-L	0,5	0	0	—	—	—
30 L-Y	0,3	0	0	1,6	30	- 80
35 Y-L	0,3	150	- 183	—	—	—
35 L-Y	0,3	0	- 100	1,9	0	- 67
40 Y-L	0,3	100	- 230	—	—	—
40 L-Y	0,4	67	- 120	1,0	38	- 38
45 Y-L	0,4	67	- 200	—	—	—
45 L-Y	0,3	77	- 177	1,1	29	- 50
50 Y-L	—	—	—	—	—	—
50 L-Y	0,4	67	- 100	1,3	25	- 56
55 Y-L	0,3	0	- 200	—	—	—
55 L-Y	0,3	100	—	1,8	0	0
60 Y-L	—	—	—	—	—	—
60 L-Y	0,3	0	- 100	1,6	0	0

TABLE 4

Estimated local impact factors, gauge 132, parapet, with plank.

Apart from these particular local effects the following general remarks may be made on the tabulated results in the APPENDIX :

- without the disturbing effect of the plank there is little dynamic effect produced in the transverse reinforcement,
- the maximum ψ value of 69 % was produced by the 16 t FBW running in the centre of the bridge from Lausanne to Yverdon,
- the maximum ψ value produced by running close to the parapet was the 41 % again caused by the 16 t FBW travelling from Lausanne to Yverdon,
- the FBW is more effective in exciting the bridge as it has the largest single axle load and the transverse bars obviously respond in a very localised fashion,
- the bridge responds more to traffic travelling Lausanne to Yverdon than Yverdon to Lausanne,
- transverse dynamic effects are always less than longitudinal effects.

5.3 NATURAL FREQUENCY

Although the tests were not intended to produce information on the natural frequency an examination of the traces permits the following remarks.

1.- Both vehicles, when running on the bridge, produced regular smooth forced vibrations in the longitudinal sense of between 3,5 and 4 hertz.

2.- Once the vehicle was off the bridge and, in theory, the 26 m span was free to vibrate in its natural modes a frequency of about 3 hertz was observed for 6 or 7 regular vibrations commencing about 2,5 seconds after the vehicles had left. This group of vibrations was then followed by a calm period and further regular though smaller oscillations. The presence of the plank did not encourage this phenomenon but merely added a more confused transition from the forced frequencies to the steady free state. It is not thought that the use of a plank would be a particularly good means of exiting bridges for purposes of examination of natural response.

3.- It was impossible to estimate the natural transverse bending frequency from the bar traces as any vibrations were of such a short duration and their effect so local that the response was most probably still forced by the immediate presence of the vehicle.

5.4 THE EXPRESSION OF DYNAMIC IMPACT, IS THE METHOD SUITABLE ?

An examination of the tables of results will reveal many cases where no value of ψ is given and, on closer inspection the reader will often see that the maximum value of the stress is less than the "static" value, hence technically a negative ψ.

It was noted that whilst the vehicles might be producing considerable vibrational response the maximum value of the median line, in theory the same as the "static" value, generally reduced with increasing speed of passage. Whilst some attempts were made to estimate these median values and calculate "true" ψ values it was accepted that they were, at best, guesses and the only valid observation was the overall trend. As ultimately in designing a bridge one is only interested in maximum stresses it is felt that factoring of the "static" value is the most useful approach as this is the only reference value one can easily estimate by calculation.

In attempting to explain this phenomena one is tempted to believe that the vehicles were wandering from their lines of travel. Although there is clearly a tendancy to give increasing clearance to the parapet this is not an influence when running on the centre of the bridge. One might similarly expect that whilst a transverse displacement of the line of travel would show reductions in the longitudinal measurements there would be some transverse bar gauges which would experience increases. As this is not the case one is forced to the conclusion that the transverse response of the span to the passage of the vehicle tends to reduce with speed and that the vibrational response in the longitudinal sense is not symmetrically additive to the "static" influence line.

6 CONCLUSIONS

A series of measurements of longitudinal deflection main beam flange stress and stresses in transverse deck reinforcing bars are presented for passages of two seperate trucks at various speeds. The majority of the tests were repeated with the vehicles being forced to pass over a 50 mm plank

simulating a discontinuity in the deck. All maximum dynamic vibrational effects are presented in terms of a "dynamic impact factor", ψ, related to the appropriate maximum static influence line values.

The following general remarks may be made in conclusion.

1.- The maximum longitudinal impact factors recorded were 16 % from the 25 t Saurer at 70 km/h on the centre line of the bridge without plank and 113 % from the 16 t FBW crossing the plank whilst running on the centre line at 10 km/h. The maximum figure of 16 % for smooth running is comparable with the value predicted by the formula in Article 18 of SIA 160 (1970) [7] which gives 16,5 % for an average span of 29 m.

2.- The maximum transverse impact factors were 5 % without and 69 % with the plank in the roadway. This conflicts with the logic of applying the same formula from SIA 160 (1970) but using "spans" of the deck slab which would predict 31 and 33 % for vehicles on a smooth running surface.

BIBLIOGRAPHY

[1] LEBET, J.-P., HIRT, M. A. Viaduc du Chêne : résultats préliminaires des essais de charge. Lausanne, Ecole polytechnique fédérale, ICOM - Construction métallique, 1979 (ICOM 055).

[2] IBAP. Viaduc du Chêne I. Lausanne, Ecole polytechnique fédérale, IBAP - Béton armé et précontraint, 1978 (IBAP - C 344).

[3] GYGAX, D., CRISINEL, M. Viaduc du Chêne : essais dynamiques avec trains de chantier. Lausanne, Ecole polytechnique fédérale, ICOM - Construction métallique, 1978 (ICOM 053).

[4] GOTTIER, M. Unpublished results of static and dynamic tests carried out 18/19 July 1978. Lausanne, Ecole polytechnique fédérale, ICOM - Construction métallique.

[5] IBAP. Auscultation des ouvrages. Essais du 13/14 octobre 1982. Viaduc du Chêne II. Ecole polytechnique fédérale, IBAP - Béton armé et précontraint, 1982.

[6] LEBET, J.-P. Unpublished data of tests carried out 13/14 October 1982. Viaduc du Chêne. Lausanne, Ecole polytechnique fédérale, ICOM - Construction métallique.

[7] SIA 160 (1970). Normes concernant les charges, la mise en service et la surveillance des constructions. Zurich, Société suisse des ingénieurs et des architectes, 1970.

APPENDIX

TABULATED RESULTS OF LONGITUDINAL DEFLECTIONS (162) LONGITUDINAL MAIN BEAM STRESSES (150) AND TRANSVERSE REINFORCING BARS (124, 113, 134 AND 132)

NOTES

The measurements presented were made at the points on the paper trace recordings corresponding to the vehicles in positions such that they were producing maximum stresses in the majority of gauges. That is with their centre of gravity of heavy axle over the gauges in midspan or over pier 11. It should be noted that in the cases of gauges 124 and 132 the stresses presented for the vehicles in the above positions by the side of the parapet are not necessarily the maximum stresses produced during the passages.

DEFINITIONS

MAX : absolute peak value including any dynamic effect,

STAT : corresponding maximum static value from 0 km/h (crawl) passage,

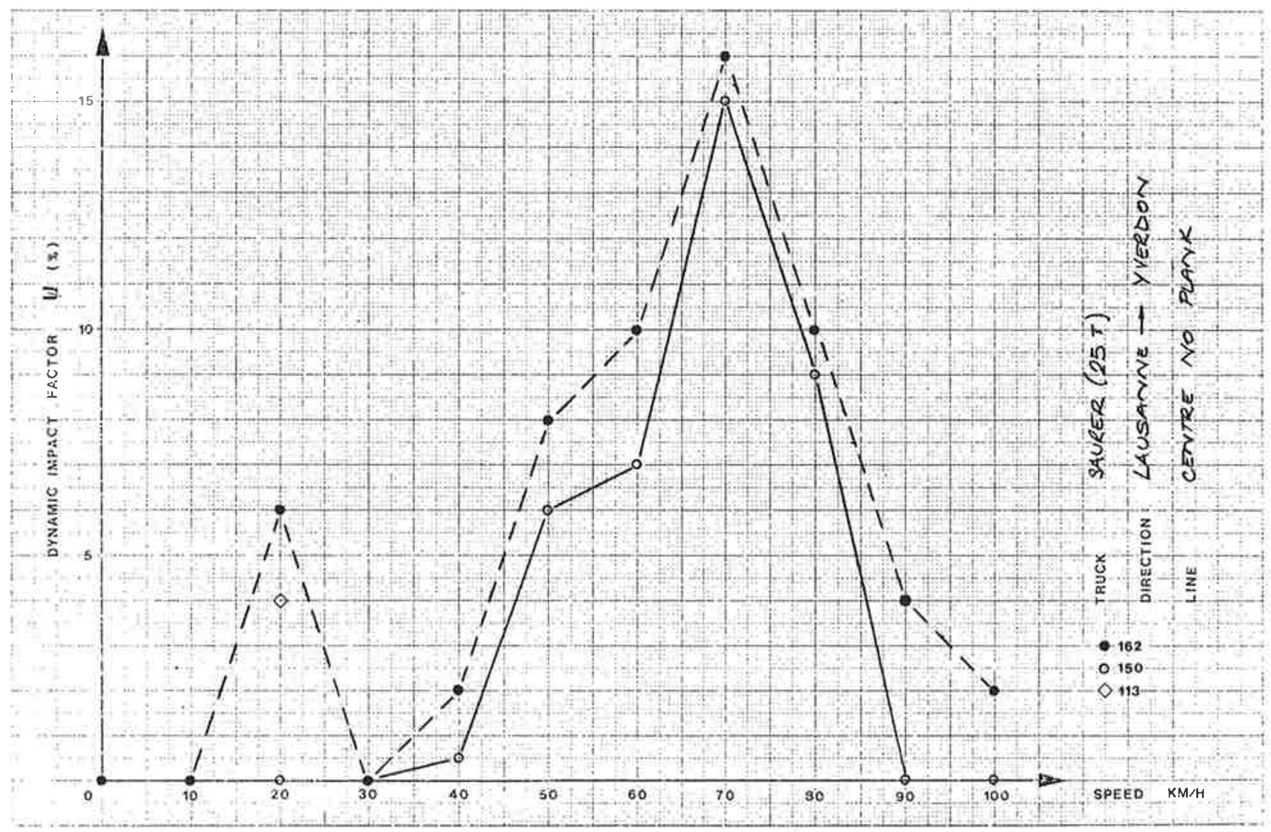
MEAN : an estimated maximum mean value of an oscillating signal given when possible,

(-) : change of stress in the compression sense.

DYNAMIC TESTING - VIADUC DU CHENE

DATE 18 OCT 82 **TRUCK** SAURER (25T) **DIRECTION** LAUSANNE → YVERDON **LINE** CENTRE WITHOUT PLANK

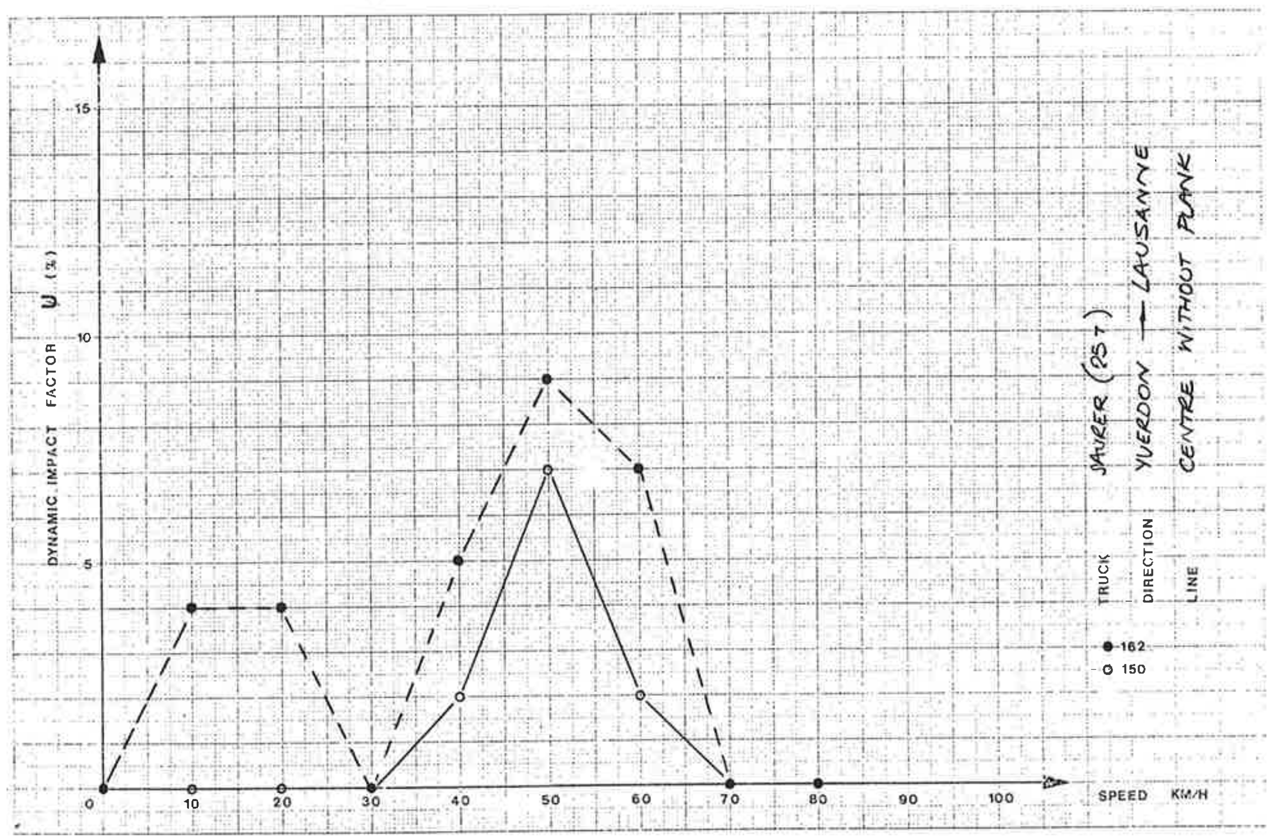
	162				150				124				113				134				132			
SPEED Km/h	MAX δ mm	STAT. δ mm	ψ %	MEAN δ mm	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²
0	2,29	2,29	0	2,29	13,7	13,7	0	13,7	-4,6	-4,6	0	-4,6	-11,5	-11,5	0	-11,5	-12,0	-12,0	0	-12,0	31	31	0	31
10	2,29	2,29	0		13,7	13,7	0		-3,8	-4,6	–		-10,7	-11,5	–		-11,5	-12,0	–		29,9	31	–	
20	2,42	2,29	6		13,7	13,7	0		-3,8	-4,6	–		-12	-11,5	4		-10,9	-12,0	–		29,0	31	–	
30	2,29	2,29	0		13,7	13,7	0		-3,8	-4,6	–		-10	-11,5	–		-10,4	-12,0	–		27,6	31	–	
40	2,34	2,29	2		13,9	13,7	1		-3,1	-4,6	–		-4,4	-11,5	–		-11,2	-12,0	–		29,0	31	–	
50	2,48	2,29	8		14,45	13,7	6		-3,1	-4,6	–		-9	-11,5	–		-10,7	-12,0	–		28,5	31	–	
60	2,53	2,29	10		14,68	13,7	7		-3,3	-4,6	–		-9	-11,5	–		-8,8	-12,0	–		27,3	31	–	
70	2,65	2,29	16		15,7	13,7	15						-10,7	-11,5	–		-9,3	-12,0	–		29,3	31	–	
80	2,53	2,29	10		14,91	13,7	9						-7,7	-11,5			-8,8	-12,0	–		31,0	31	–	
90	2,38	2,29	4		13,7	13,7	0						-8,4	-11,5			-9,8	-12,0	–		31,0	31	–	
100	2,34	2,29	2		11,06	13,7	–						-8,9	-11,5			-10,4	-12,0	–		32,7	31	5	



DYNAMIC TESTING - VIADUC DU CHENE

DATE 18 OCT. 82 **TRUCK** SAURER (25T) **DIRECTION** YVERDON → LAUSANNE **LINE** CENTRE WITHOUT PLANK

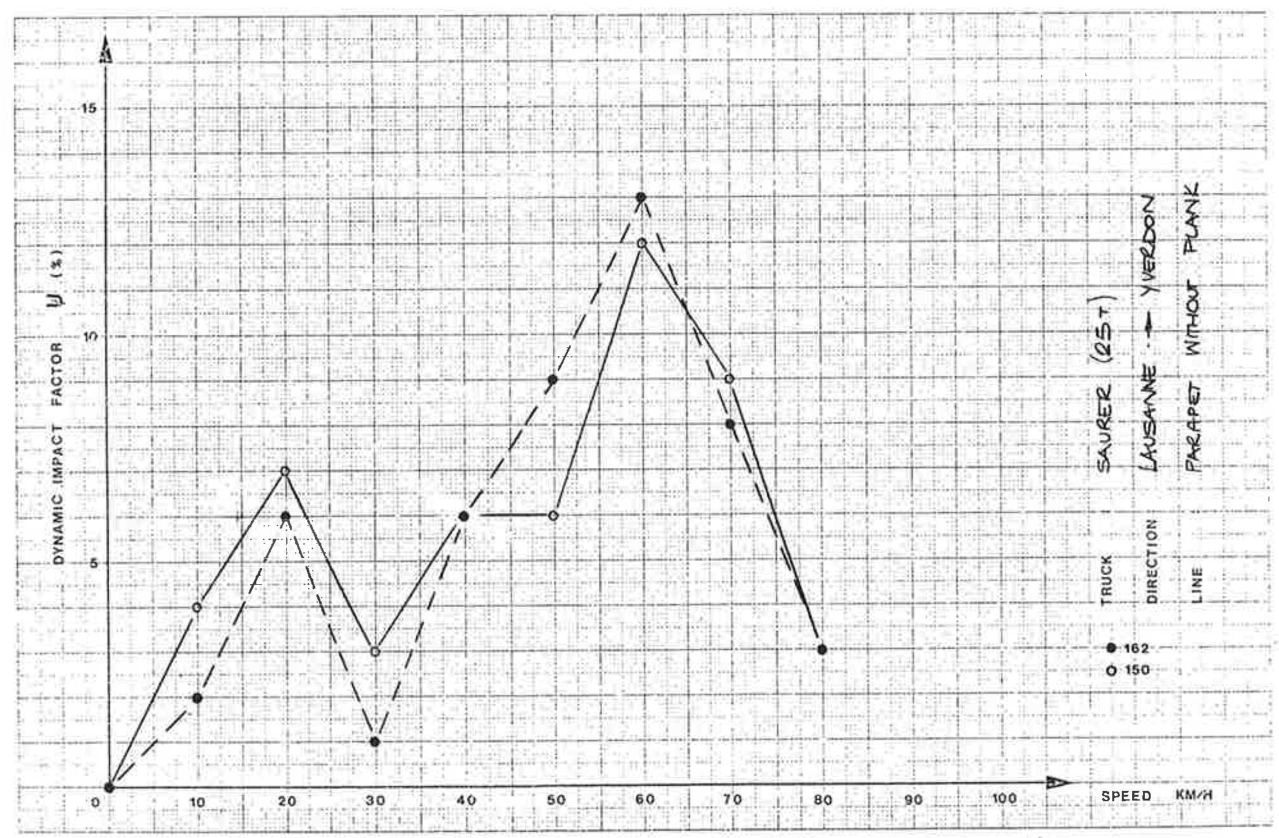
	162				150				124				113				134				132			
SPEED Km/h	MAX δ mm	STAT. δ mm	ψ %	MEAN δ mm	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²
0	2,32	2,32	0	2,32	13,7	13,7	0	13,7	-4,6	-4,6	0	-4,6	-11,5	-11,5	0	-11,5	-12,6	-12,6	0	12,6	31	31	0	31
10	2,38	2,32	4		13,7	13,7	0		-3,6	-4,6	–		-10,7	-11,5			-11,5	-12,6	–		29,8	31	–	
20	2,38	2,32	4		13,7	13,7	0		-3,8	-4,6	–		-10,7	-11,5			-10,9	-12,6	–		28,8	31		
30	2,32	2,32	0		13,7	13,7	0		-4,0	-4,6	–		-10	-11,5			-10,1	-12,6	–		28,2	31		
40	2,43	2,32	5		13,98	13,7	2		-2,9	-4,6	–		-10	-11,5			-7,1	-12,6	–		27,1	31		
50	2,52	2,32	9		14,68	13,7	7		-3,6	-4,6	–		-10,7	-11,5			-9,3	-12,6	–		26,2	31		
60	2,49	2,32	7		13,97	13,7	2		-3,6	-4,6	–		-10,7	-11,5			-9,8	-12,6	–		27,2	31		
70	2,32	2,32	0		13,7	13,7	0		-2,9	-4,6	–		-8,9	-11,5			-9,2	-12,6	–		27,1	31		
80	2,32	2,32	0		13,7	13,7	0		–				-9,2	-11,5			-9,1	-12,6	–		27,1	31		



DYNAMIC TESTING - VIADUC DU CHENE

DATE 18 OCT 82 **TRUCK** SAURER (25T) **DIRECTION** LAUSANNE → YVERDON **LINE** PARAPET WITHOUT PLANK

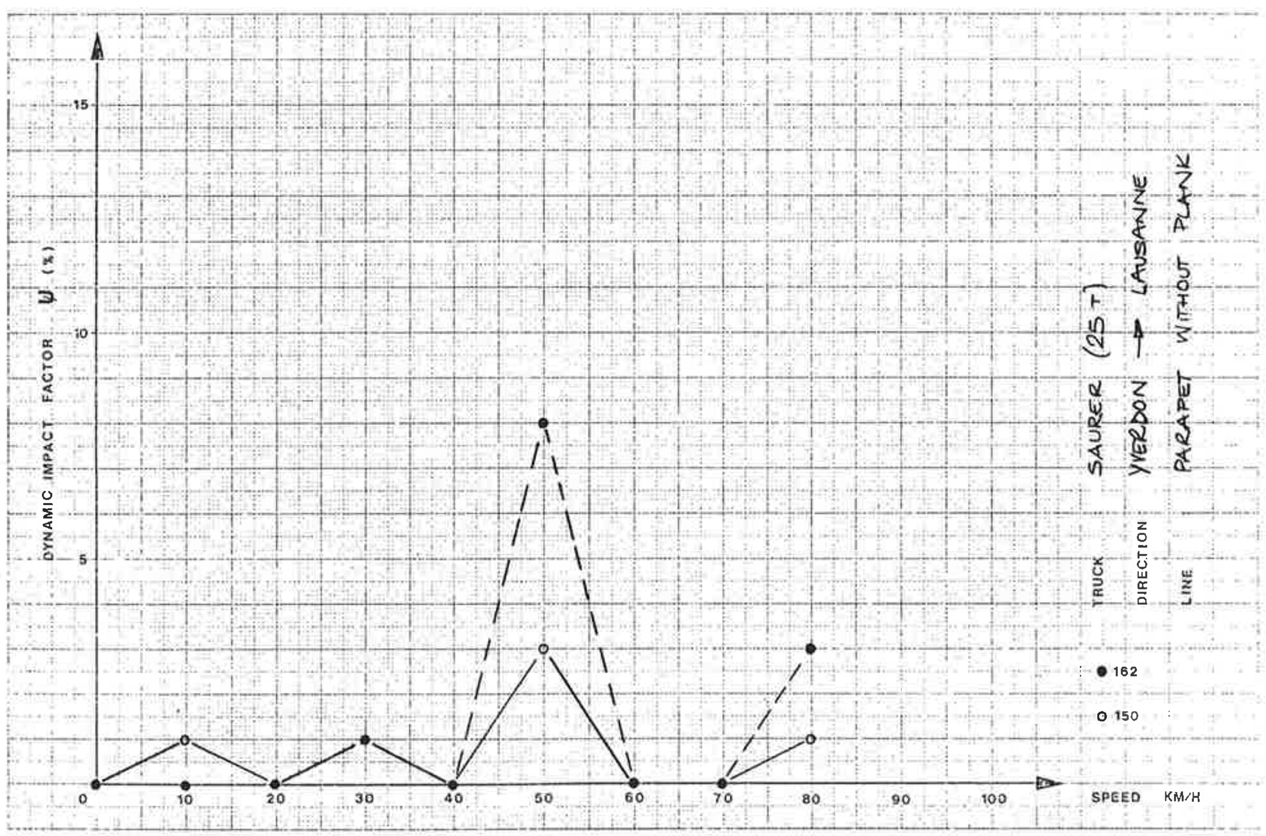
	162				150				124				113				134				132			
SPEED Km/h	MAX δ mm	STAT. δ mm	ψ %	MEAN δ mm	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²
0	3,12	3,12	0	3,12	19,6	19,6	0	19,6	1,7	1,7			-1,0	-1,0			/	/			-0,3	-0,3		
10	3,18	3,12	2	3,10	20,3	19,6	4	19,5	1,6				-0,8				/				/			
20	3,29	3,12	6	3,11	20,9	19,6	7	19,9	1,4				-0,8				/				/			
30	3,16	3,12	1	3,10	20,1	19,6	3	19,5	1,3				/				/				/			
40	3,30	3,12	6	3,10	20,7	19,6	6	19,4	1,3				/				-0,5				/			
50	3,40	3,12	9	3,10	20,7	19,6	6	19,0	/				/				-0,6				/			
60	3,52	3,12	13	3,07	21,9	19,6	12	18,8	/				/				/				/			
70	3,38	3,12	8	3,01	21,3	19,6	9	18,6	/				/				/				/			
80	3,20	3,12	3	2,97	20,2	19,6	3	18,6	/				/				/				/			



DYNAMIC TESTING - VIADUC DU CHENE

DATE 18 OCT 82 **TRUCK** SAURER (25T) **DIRECTION** YVERDON → LAUSANNE **LINE** PARAPET WITHOUT PLANK

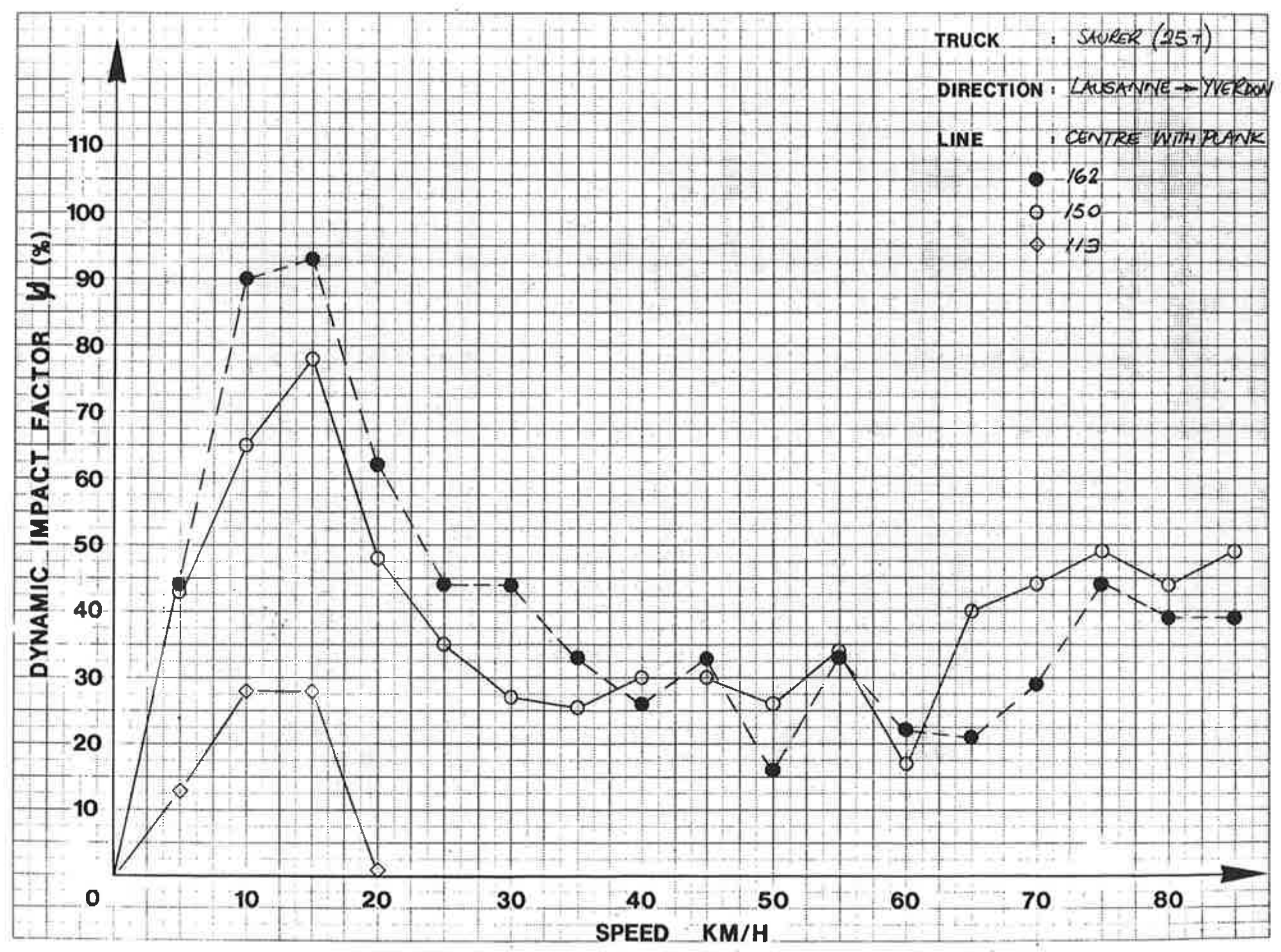
	162				150				124				113				134				132			
SPEED Km/h	MAX. δ mm	STAT. δ mm	ψ %	MEAN δ mm	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²
0	3,21	3,21	0	3,21	20,6	20,6	0	20,6	1,7	1,7			-1,7	-1,7			-0,4	-0,4				-0,6		
10	3,22	3,21	0	3,17	20,9	20,6	1	20,3	1,7				-0,8									—		
20	3,22	3,21	0	3,12	20,7	20,6	0	19,9	1,4				-1,2									—		
30	3,24	3,21	1	3,12	20,9	20,6	1	20,1	1,4				-1,4									—		
40	3,19	3,21	—	3,13	20,5	20,6	—	19,9	1,3				-1,0									—		
50	3,47	3,21	8	3,13	21,3	20,6	3	19,4	—				—									—		
60	3,20	3,21	—	3,07	20,7	20,6	0	19,4	—				—									—		
70	3,21	3,21	0	3,05	20,1	20,6	—	19,0	—				—									—		
80	3,29	3,21	3	3,00	20,9	20,6	1	18,8	1,3				—									—		



DYNAMIC TESTING - VIADUC DU CHENE

DATE 18 OCT 82 **TRUCK** SAURER (25T) **DIRECTION** LAUSANNE → YVERDON **LINE** CENTRE WITH PLANK

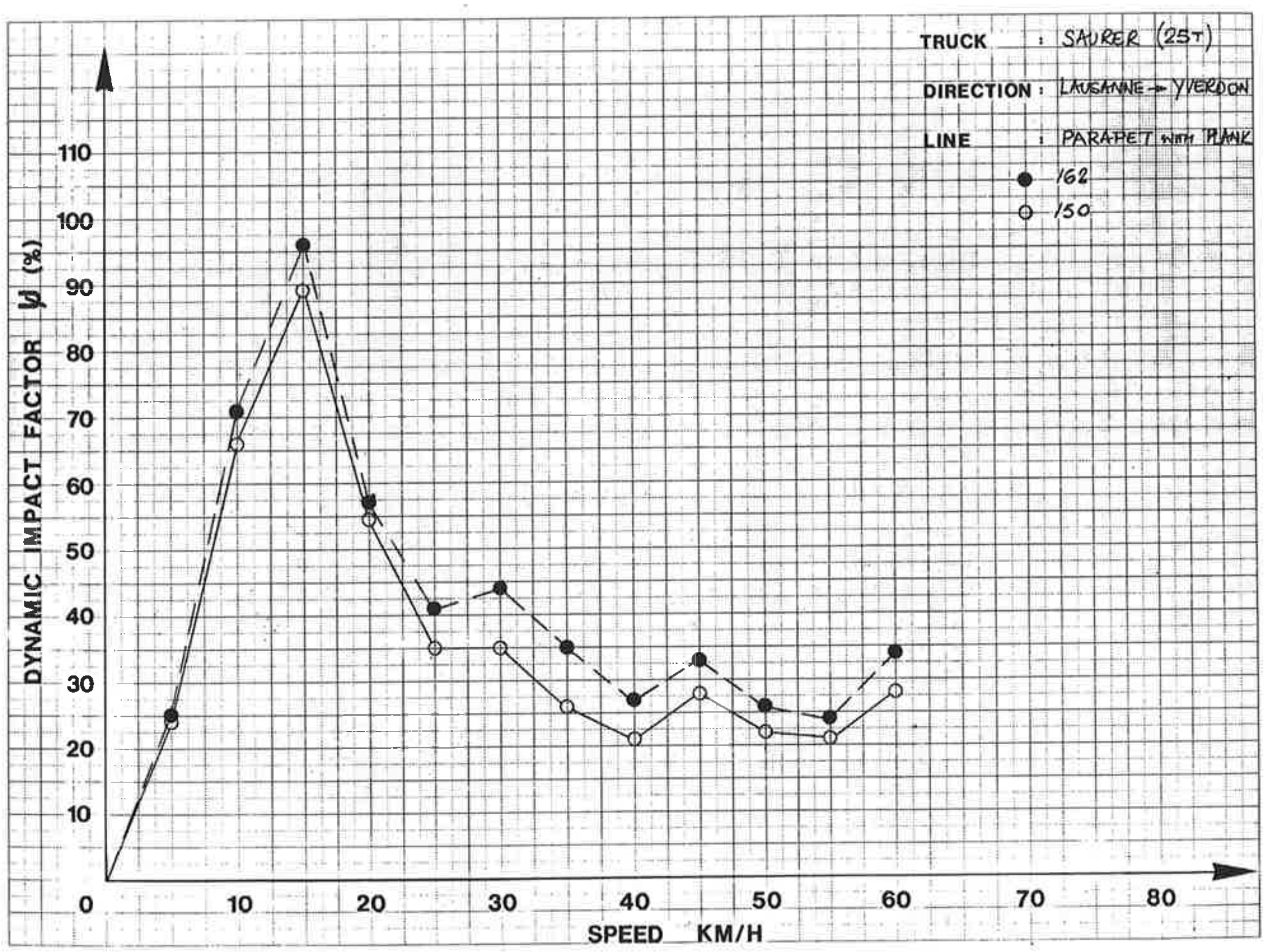
	162				150				124				113				134				132			
SPEED Km/h	MAX. δ mm	STAT. δ mm	ψ %	MEAN δ mm	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²
0	2,29	2,29	0	2,29	13,37	13,7	0	13,37	-4,4	-4,4	0	-4,4	-12,2	-12,2	0	-12,2	-15,2	-15,2	0	-15,2	33,1	33,1	0	33,1
5	3,30	2,29	44		19,64	13,7	43		-5,3	-4,4	20	-4,2	-13,8	-12,2	13	-11,9	-15,6	-15,2		—	33,1	33,1		32,2
10	4,35	2,29	90		22,57	13,7	65		-5,6	-4,4	27	-3,9	-15,6	-12,2	28	-11,3	-14,9	-15,2		-14,5	32,3	33,1		31,2
15	4,41	2,29	93		24,34	13,7	78		-5,8	-4,4	32	-3,9	-15,6	-12,2	28	-10,9	-15,0	-15,2		-13,8	33,9	33,1	2	30,6
20	3,70	2,29	62		20,23	13,7	48		-4,3	-4,4		-3,2	-12,3	-12,2	1	-9,5	-13,5	-15,2		-13,3	31,1	33,1		30,2
25	3,30	2,29	44		18,45	13,7	35		-4,4	-4,4		-3,4	-12,1	-12,2		-9,8	-13,7	-15,2		-13,4	31,7	33,1		30,3
30	3,30	2,29	44		17,44	13,7	27		-4,2				-11,8				-13,3	-15,2			30,4	33,1		
35	3,05	2,29	33		17,21	13,7	26		-4,4				-11,5				-13,1	-15,2			30,5	33,1		
40	2,89	2,29	26		17,79	13,7	30		-4,3				-11,2				-13,6	-15,2			31,9	33,1		
45	3,05	2,29	33		17,79	13,7	30		-4,2				-11,2				-13,1	-15,2			30,9	33,1		
50	2,66	2,29	16		17,20	13,7	26		-4,1				-10,9				-13,4	-15,2			32,4	33,1		
55	3,05	2,29	33		18,37	13,7	34		-4,2				-11,4				-12,0	-15,2			27,5	33,1		
60	2,80	2,29	22		16,04	13,7	17		-4,4				-11,2				-11,9	-15,2			29,6	33,1		
65	2,77	2,29	21		19,2	13,7	40		-3,8				-11,8				-10,9	-15,2			30,0	33,1		
70	2,95	2,29	29		19,78	13,7	44		-4,0				-11,2				-11,6	-15,2			30,7	33,1		
75	3,30	2,29	44		20,46	13,7	49		-4,4				-11,6				-12,1	-15,2			31,9	33,1		
80	3,18	2,29	39		19,78	13,7	44		-4,1				-11,0				-11,8	-15,2			31,2	33,1		
85	3,19	2,29	39		20,46	13,7	49		-4,2				-10,6				-12,1	-15,2			32,0	33,1		



DYNAMIC TESTING - VIADUC DU CHENE

DATE 18 OCT 82 **TRUCK** SAURER (25T) **DIRECTION** LAUSANNE → YVERDON **LINE** PARAPET WITH PLANK

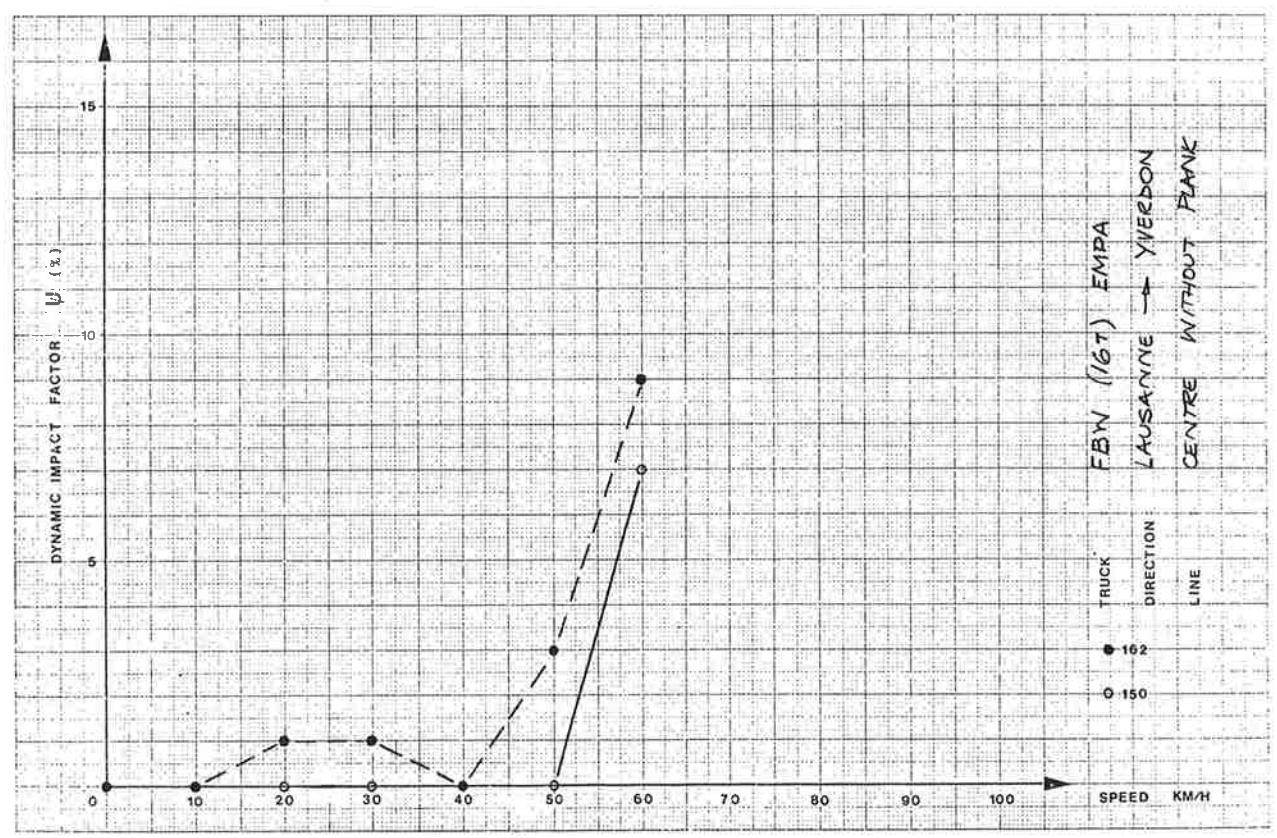
	162				150				124				113				134				132			
SPEED Km/h	MAX δ mm	STAT. δ mm	ψ %	MEAN δ mm	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²
0	3,19	3,19	0	3,19	20,0	20,0	0	20,0	—				—				—				-0,3	0,9		
5	4,0	3,19	25	3,23	23,8	20,0	24	19,8	—				—				—				—			
10	5,46	3,19	71	3,30	34,3	20,0	71	20,3	—				—				—				—			
15	6,25	3,19	96	3,36	37,8	20,0	89	20,9	—				—				—				—			
20	5,00	3,19	57	3,21	30,9	20,0	54	20,7	—				—				—				—			
25	4,51	3,19	41	3,30	27	20,0	35	20,7	—				—				—				—			
30	4,58	3,19	44	3,27	21,1	20,0	35	20,2	—				—				—				—			
35	4,31	3,19	35	3,26	25,3	20,0	26	19,9	—				—				—				—			
40	4,05	3,19	27	3,21	24,2	20,0	21	19,2	—				—				—				—			
45	4,26	3,19	33	3,15	25,7	20,0	28	19,2	—				—				—				—			
50	4,02	3,19	26	3,21	24,4	20,0	22	19,2	—				—				—				—			
55	3,96	3,19	24	3,13	24,3	20,0	21	19,2	—				—				—				—			
60	4,27	3,19	34	3,12	25,7	20,0	28	19,2	—				—				—				—			



DYNAMIC TESTING - VIADUC DU CHENE

DATE 15 OCT 82 **TRUCK** FBW (16T) EMPA **DIRECTION** LAUSANNE → YVERDON **LINE** CENTRE WITHOUT PLANK.

	162				150				124				113				134				132			
SPEED Km/h	MAX δ mm	STAT. δ mm	ψ %	MEAN δ mm	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²
0	1,43	1,43	0	1,43	8,3	8,3	0	8,3	-2,5				-7,7				-7,4				16,9			
10	1,43	1,43	0	1,39	8,3	8,3	0	8,0	-2,3				-6,6				-6,6				16,1			
20	1,45	1,43	1	1,37	8,2	8,3	–	7,7	—				-6,4				-6,8				15,4			
30	1,45	1,43	1	1,37	8,3	8,3	0	7,8	-1,8				-6,3				-6,0				15,9			
40	1,36	1,43	–	1,30	7,7	8,3	–	7,4	-2,0				-6,2				-6,2				15,8			
50	1,47	1,43	3	1,29	8,3	8,3	0	7,2	-1,6				-5,7				-5,8				13,8			
60	1,56	1,43	9	1,35	8,9	8,3	7	7,3	-1,6				-5,7				-5,5				14,3			

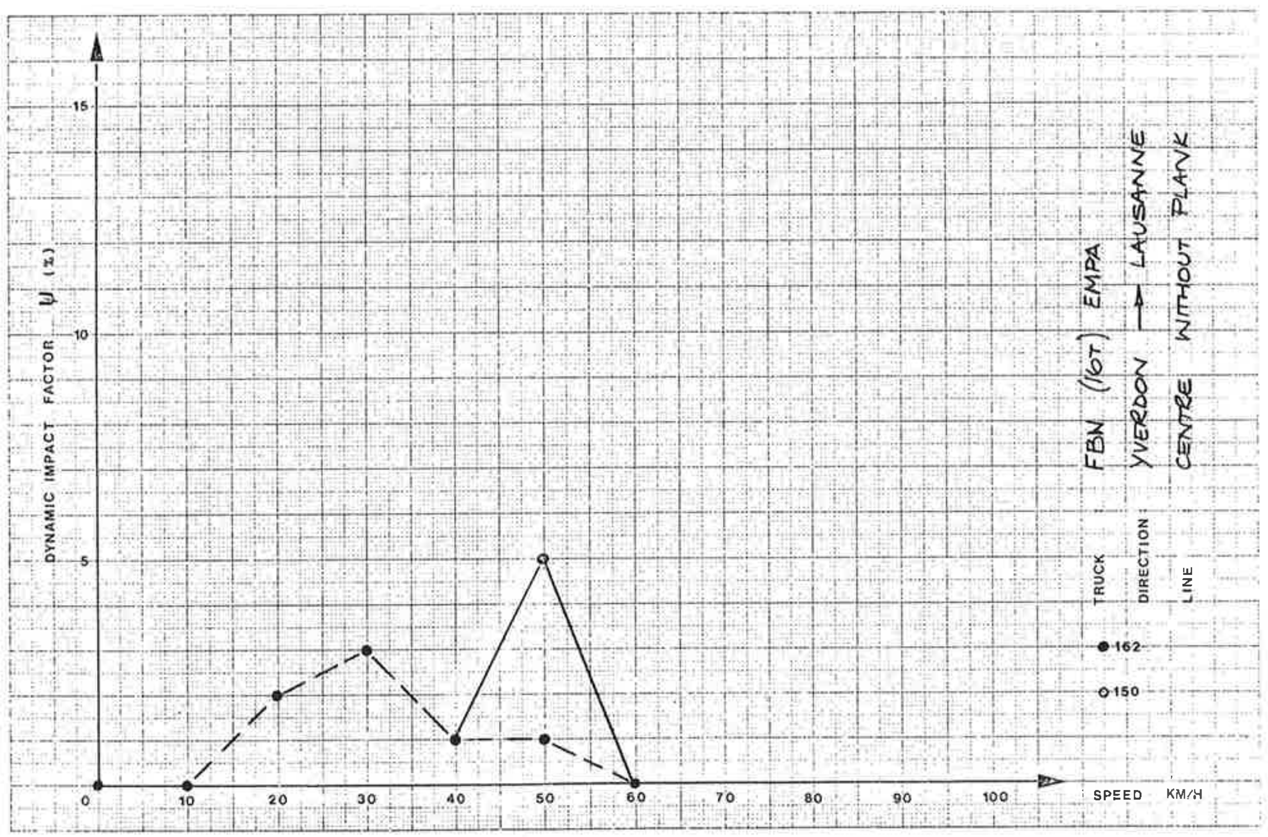


DYNAMIC TESTING - VIADUC DU CHENE

DATE 15 OCT 82 **TRUCK** FBW (16T) EMPA **DIRECTION** YVERDON → LAUSANNE **LINE** CENTRE WITHOUT PLANK

	162				150				124				113				134				132			
SPEED Km/h	MAX δ mm	STAT. δ mm	ψ %	MEAN δ mm	MAX σ N/mm^2	STAT σ N/mm^2	ψ %	MEAN σ N/mm^2	MAX σ N/mm^2	STAT σ N/mm^2	ψ %	MEAN σ N/mm^2	MAX σ N/mm^2	STAT σ N/mm^2	ψ %	MEAN σ N/mm^2	MAX σ N/mm^2	STAT σ N/mm^2	ψ %	MEAN σ N/mm^2	MAX σ N/mm^2	STAT σ N/mm^2	ψ %	MEAN σ N/mm^2
0	1,52	1,52	0	1,52	8,6	8,6	0	8,6	-2,6				-7,7				-7,9				17,2			
10	1,51	1,52	–	1,46	8,5	8,6	–	8,4																
20	1,55	1,52	2	1,50	8,8	8,6	2	8,5													15,7			
30	1,57	1,52	3	1,44	8,9	8,6	3	8,3									-6,7				16,2			
40	1,54	1,52	1	1,44	8,7	8,6	1	8,2	-1,9				-5,8				-6,0				15,1			
*50	1,54	1,52	1	1,36	9,0	8,6	5	7,9					-6,1				-5,7				14,2			
60	1,50	1,52	–	1,42	8,2	8,6	–	7,9	-1,7				-5,8				-5,7				15,0			

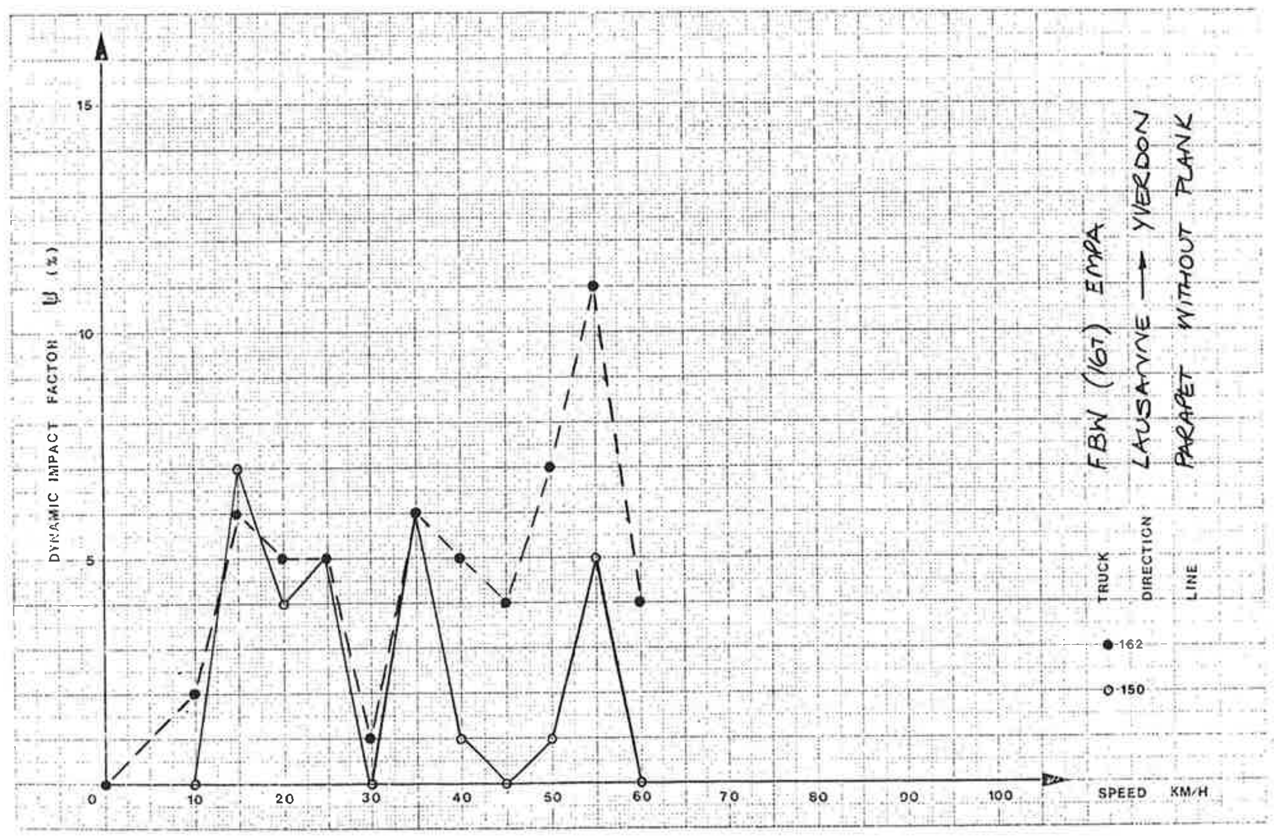
* ACTUALLY 48 Km/h.



DYNAMIC TESTING - VIADUC DU CHENE

DATE 15 OCT 82 **TRUCK** FBW (16T) EMPA **DIRECTION** LAUSANNE → YVERDON **LINE** PARAPET WITHOUT PLANK.

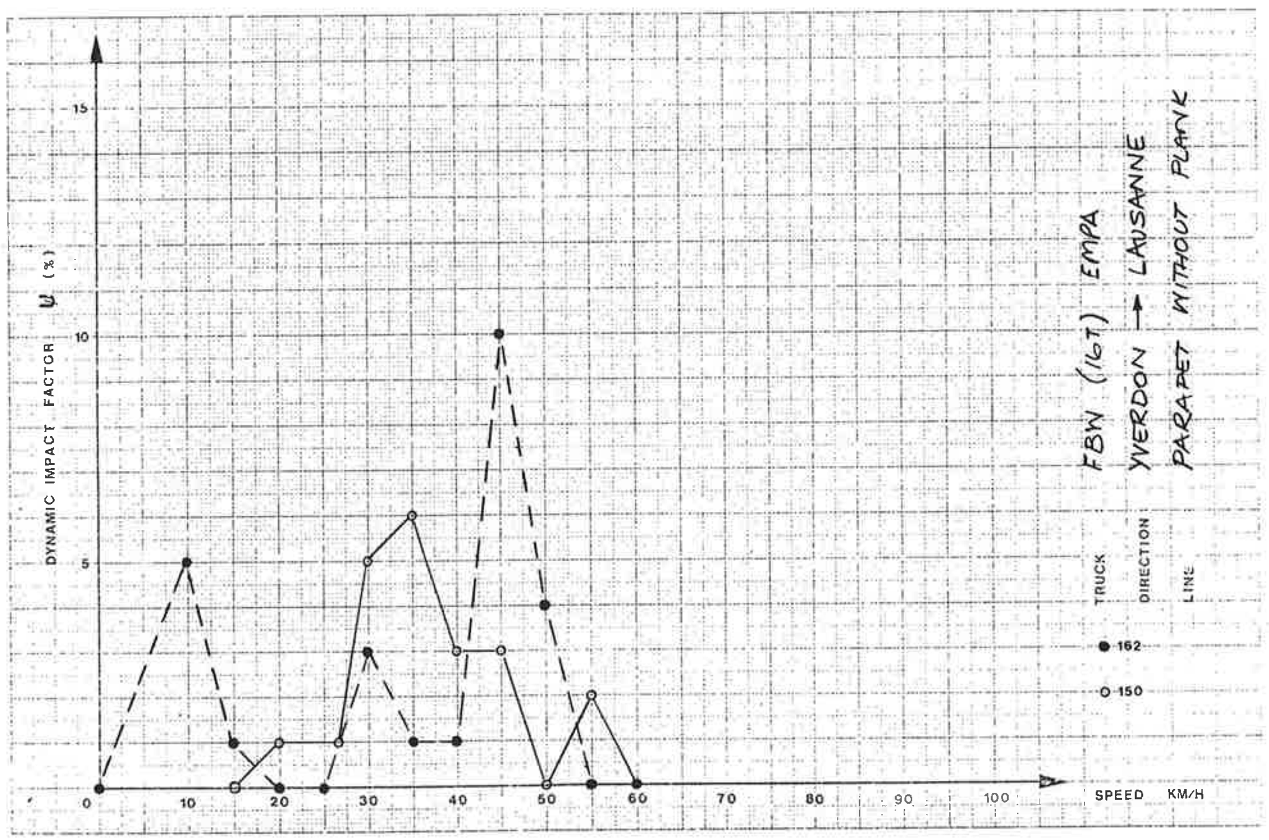
	162				150				124				113				134				132			
SPEED Km/h	MAX δ mm	STAT. δ mm	ψ %	MEAN δ mm	MAX σ N/mm^2	STAT σ N/mm^2	ψ %	MEAN σ N/mm^2	MAX σ N/mm^2	STAT σ N/mm^2	ψ %	MEAN σ N/mm^2	MAX σ N/mm^2	STAT σ N/mm^2	ψ %	MEAN σ N/mm^2	MAX σ N/mm^2	STAT σ N/mm^2	ψ %	MEAN σ N/mm^2	MAX σ N/mm^2	STAT σ N/mm^2	ψ %	MEAN σ N/mm^2
0	1,96	1,96	0	1,96	12,2	12,2	0	12,2	–	1,6			–	- 1,0			–				–			
10	2,00	1,96	2	1,95	12,3	12,2	1	12,0	–				–				–				–			
15	2,07	1,96	6	1,94	13,1	12,2	7	12,1	–				–				–				–			
20	2,06	1,96	5	1,90	12,7	12,2	4	11,7	1,4				–				-0,2				–			
25	2,05	1,96	5	1,91	12,8	12,2	5	11,8	1,3				–				-0,1				–			
30	1,97	1,96	1	1,92	11,9	12,2	–	11,6	1,3				–				-0,3				–			
35	2,07	1,96	6	1,92	12,9	12,2	6	11,6	1,3				–				-0,2				–			
40	2,06	1,96	5	1,90	12,3	12,2	1	11,5	1,0				–				–				–			
45	2,03	1,96	4	1,88	12,1	12,2	0	11,1	1,1				–				-0,4				–			
50	2,07	1,96	7	1,88	12,3	12,2	1	11,4	0,8				–				-0,3				–			
55	2,17	1,96	11	1,95	12,8	12,2	5	11,7	1,2				–				-0,3				–			
60	2,03	1,96	4	1,97	12,2	12,2	0	12,1	1,0				–				–							



DYNAMIC TESTING - VIADUC DU CHENE

DATE 15 OCT 82 **TRUCK** FBW (16T) EMPA **DIRECTION** YVERDON → LAUSANNE **LINE** PARAPET WITHOUT PLANK.

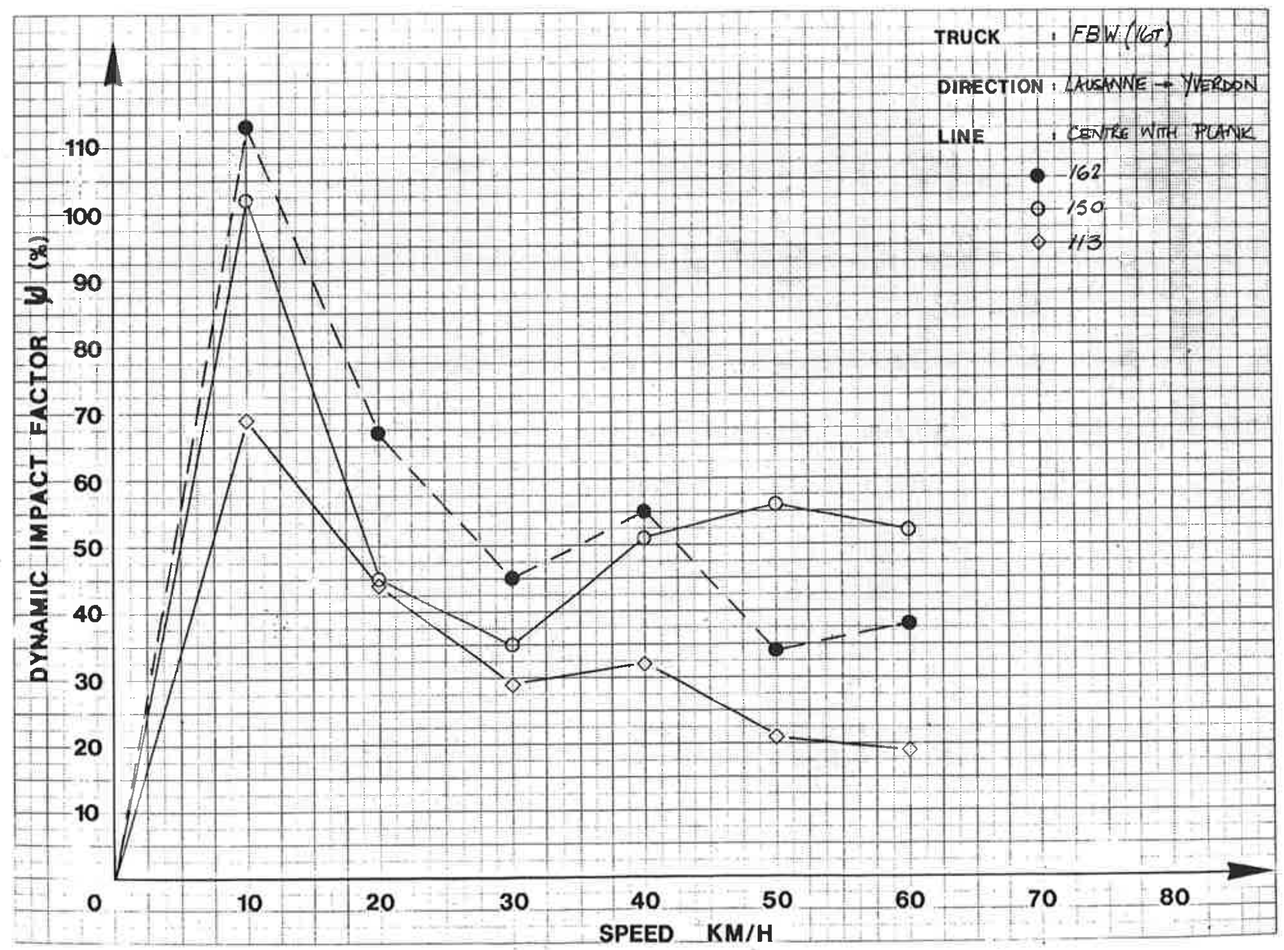
	162				150				124				113				134				132			
SPEED Km/h	MAX. δ mm	STAT. δ mm	ψ %	MEAN δ mm	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²
0	2,04	2,04	0	2,04	12,5	12,5	0	12,5	1,8	1,8			/	-0,9			/	-0,6			/			
10	2,15	2,04	5	2,04	13,1	12,5	5	12,6	/				/				/				/			
15	2,05	2,04	1	1,99	12,5	12,5	0	12,2	/				/				/				/			
20	2,04	2,04	0	1,96	12,6	12,5	1	12,1	1,5				/				/				/			
25	1,96	2,04	–	1,96	12,6	12,5	1	12,1	1,6				/				/				/			
30	2,10	2,04	3	1,96	13,1	12,5	5	12,0	1,3				/				/				/			
35	2,07	2,04	1	1,93	13,2	12,5	6	12,0	1,1				/				-0,4				/			
40	2,07	2,04	1	1,93	12,9	12,5	3	11,6	1,3				/				-0,2				/			
45	2,34	2,04	10	1,97	12,9	12,5	3	11,8	1,3				/				/				/			
50	2,13	2,04	4	1,99	12,1	12,5	-	11,7	1,1				/				-0,6				/			
55	2,04	2,04	0	1,98	12,7	12,5	2	12,3	1,2				/				-0,6				/			
60	2,03	2,04	0	1,91	12,0	12,5	-	11,5	1,0				/				-0,2				/			



DYNAMIC TESTING - VIADUC DU CHENE

DATE 15 OCT 82 **TRUCK** FBW (16T) EMPA **DIRECTION** LAUSANNE → YVERDON **LINE** CENTRE WITH PLANK

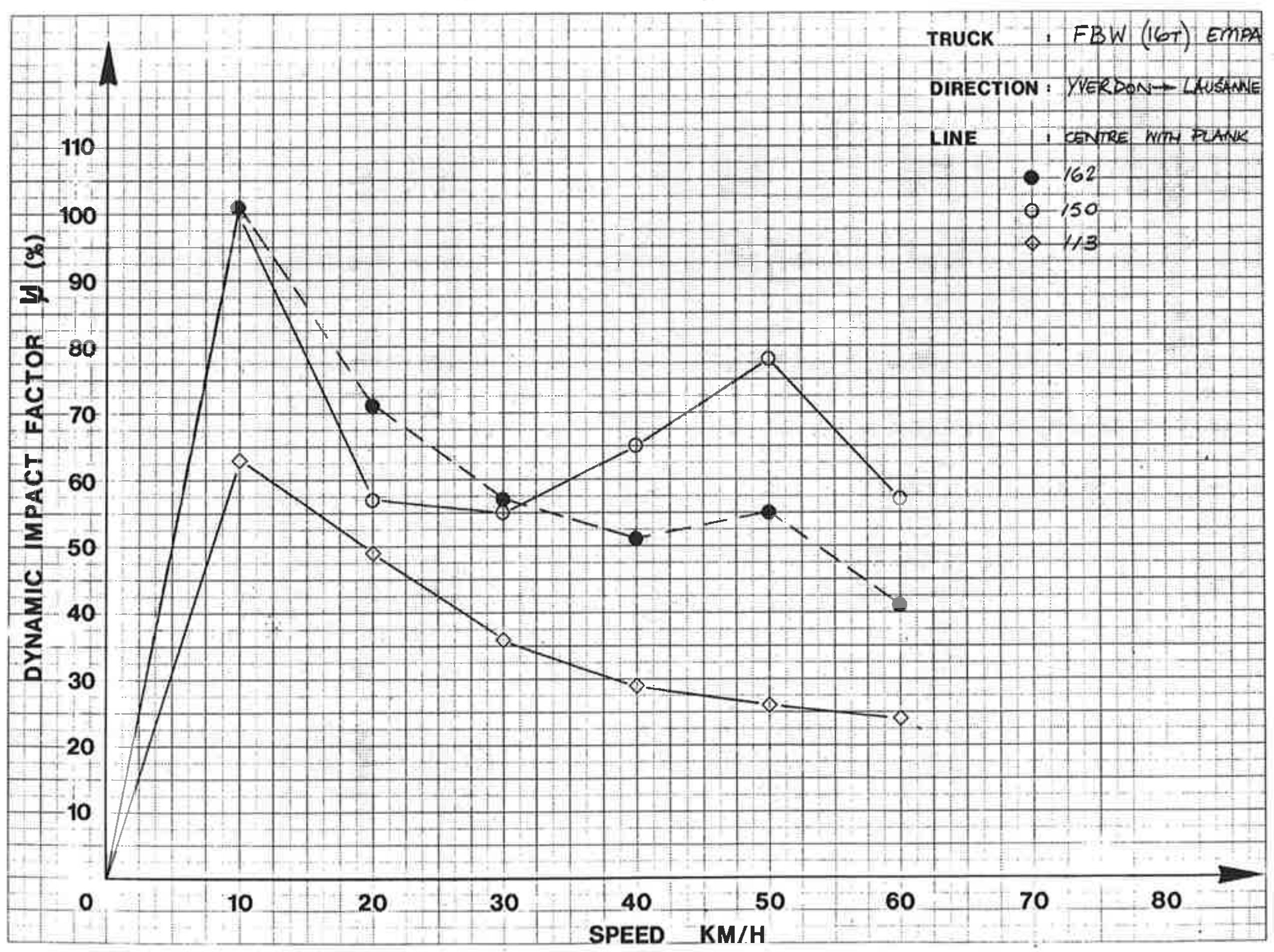
	162				150				124				113				134				132			
SPEED Km/h	MAX. δ mm	STAT. δ mm	ψ %	MEAN δ mm	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²
0	1,43	1,43	0	1,43	8,3	8,3	0	8,3	-2,5	-2,5	0	-2,5	-7,7	-7,7	0	-7,7	-7,9	-7,9	0	7,9	16,3			
10	3,04	1,43	113	1,41	16,8	8,3	102	8,0	-3,1	-2,5	24	-1,9	-13,0	-7,7	69	-9,1	-7,1	-7,9			16,1			
20	2,39	1,43	67	1,38	12,0	8,3	45	7,7	-2,5	-2,5			-11,1	-7,7	44		-6,6	-7,9			14,8			
30	2,08	1,43	45	1,42	11,2	8,3	35	8,0	-2,5	-2,5			-9,9	-7,7	29		-6,1	-7,9			15,8			
40	2,12	1,43	55	1,25	12,5	8,3	51	7,2	-2,3	-2,5			-10,2	-7,7	32		-6,5	-7,9			15,7			
50	1,88	1,43	34	1,32	12,4	8,3	56	7,3	-2,3	-2,5			-9,3	-7,7	21		-5,9	-7,9			13,8			
60	1,98	1,43	38	1,28	12,6	8,3	52	7,5	-2,5	-2,5			-9,2	-7,7	19		-5,7	-7,9			14,7			



DYNAMIC TESTING - VIADUC DU CHENE

DATE 15 OCT 82 **TRUCK** FBW (16T) EMPA **DIRECTION** YVERDON → LAUSANNE **LINE** CENTRE WITH PLANK

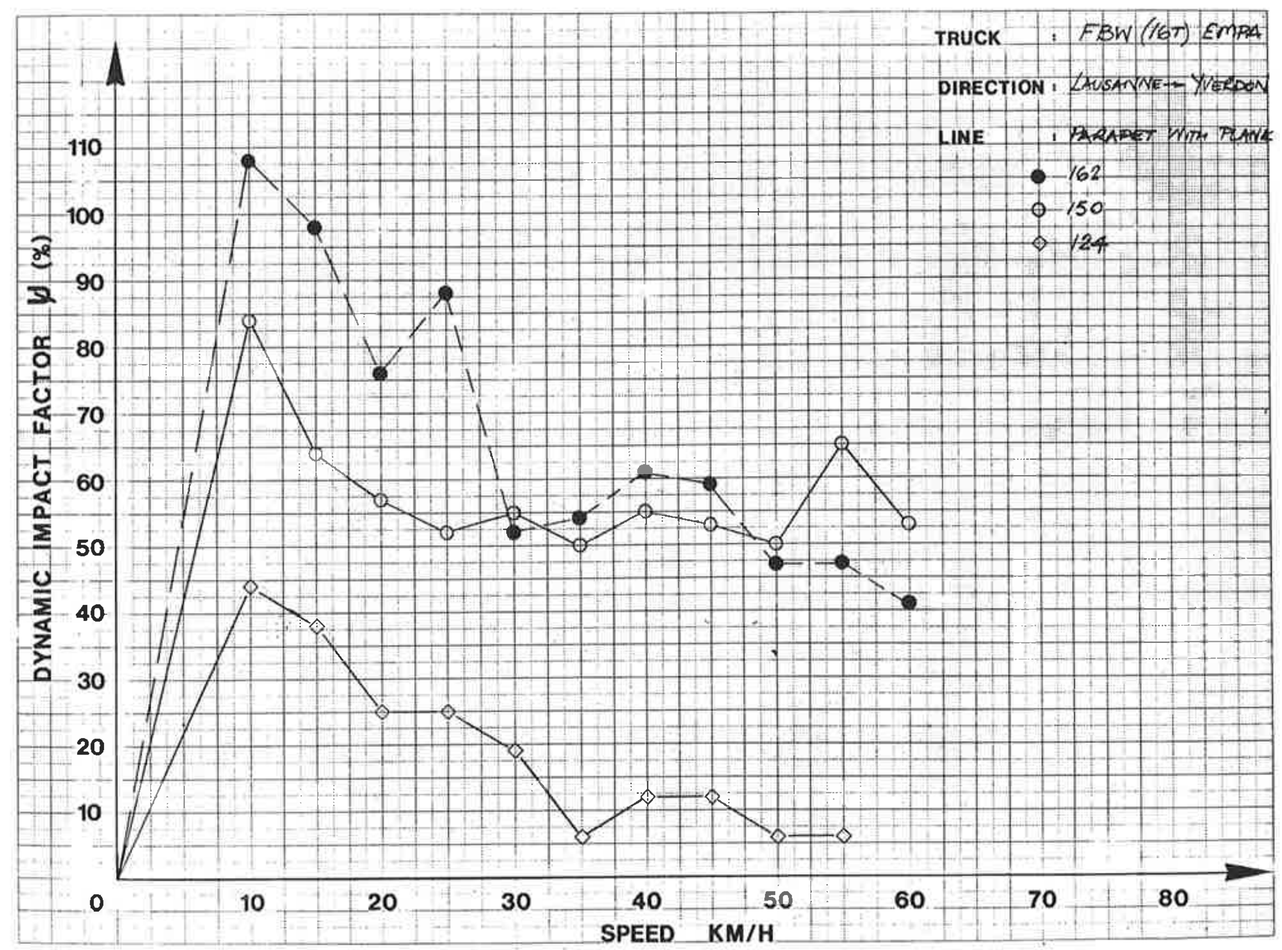
	162				150				124				113				134				132			
SPEED Km/h	MAX. δ mm	STAT. δ mm	Ψ %	MEAN δ mm	MAX σ N/mm²	STAT σ N/mm²	Ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	Ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	Ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	Ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	Ψ %	MEAN σ N/mm²
0	1,52	1,52	0	1,52	8,6	8,6	0	8,6	-2,6	-2,6	0	-2,6	-7,7	-7,7	0	-7,7	-8,1	-8,1	0	-8,1	17,2	17,2	0	17,2
10	3,05	1,52	101	1,56	17,4	8,6	102	8,8	-3,1	-2,6	19	-1,9	-12,5	-7,7	63	-8,5	-7,5	-8,1			17,0	17,2		
20	2,60	1,52	71	1,51	13,5	8,6	57	8,7	-2,7	-2,6	4		-11,5	-7,7	49		-7,1	-8,1			15,9	17,2		
30	2,38	1,52	57	1,48	13,3	8,6	55	8,2	-2,6	-2,6			-10,5		36		-6,7	-8,1			15,5	17,2		
40	2,29	1,52	51	1,59	14,2	8,6	65	8,9	-2,6	-2,6			-9,9		29		-6,1	-8,1			17,0	17,2		
50	2,36	1,52	55	1,35	15,3	8,6	78	7,7	-2,5	-2,6			-9,7		26		-7,6	-8,1			18,8	17,2	9,3	
60	2,15	1,52	41	1,39	13,9	8,6	62	7,9	-2,5	-2,6			-9,5		24		-5,8	-8,1			14,8	17,2		



DYNAMIC TESTING - VIADUC DU CHENE

DATE 15 OCT 82 **TRUCK** FBW (16T) EMPA **DIRECTION** LAUSANNE → YVERDON **LINE** PARAPET WITH PLANK.

	162				150				124				113				134				132			
SPEED Km/h	MAX. δ mm	STAT. δ mm	Ψ %	MEAN δ mm	MAX σ N/mm²	STAT σ N/mm²	Ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	Ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	Ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	Ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	Ψ %	MEAN σ N/mm²
0	1,95	1,95	0	1,95	12,1	12,1	0	12,1	1,6	1,6	0		-1,0	-1,0			—				-0,8			
10	4,06	1,95	108	1,98	22,3	12,1	84	12,1	2,3		44		-1,0				—				-0,1			
15	3,86	1,95	98	1,98	19,8	12,1	64	12,1	2,2		38		-1,2		20		-0,2				-0,5			
20	3,44	1,95	76	1,90	19,0	12,1	57	11,4	2,0		25		-1,1		10		—				—			
25	3,66	1,95	88	1,94	18,4	12,1	52	11,4	2,0		25		-1,0				-0,2				-0,5			
30	2,96	1,95	52	2,01	18,7	12,1	55	11,8	1,9		19		-0,8				—				-0,7			
35	3,00	1,95	54	1,95	18,2	12,1	50	11,4	1,7		6		-0,7				—				-0,7			
40	3,14	1,95	61	2,05	18,7	12,1	55	12,2	1,8		12		-0,8				—				-0,7			
45	3,10	1,95	59	1,9	18,5	12,1	53	11,1	1,8		12		-0,8				-0,4				-1,0			
50	2,87	1,95	47	1,91	18,1	12,1	50	12,0	1,7		6		—				-0,4				-0,8			
55	2,86	1,95	47	1,95	20,0	12,1	65	12,2	1,7		6		-0,8				—				-0,9			
60	2,74	1,95	41	1,90	19,5	12,1	53	11,8	—				—				—				-1,0			



DYNAMIC TESTING - VIADUC DU CHENE

DATE 15 OCT. 82 **TRUCK** FBW (16 T) EMPA **DIRECTION** YVERDON → LAUSANNE **LINE** PARAPET WITH PLANK

	162				150				124				113				134				132			
SPEED Km/h	MAX. δ mm	STAT. δ mm	ψ %	MEAN δ mm	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²	MAX σ N/mm²	STAT σ N/mm²	ψ %	MEAN σ N/mm²
0	2,02	2,02	0	2,02	12,5	12,5	0	12,5	1,8	1,8			-1,0	-1,0			—				—	-1,0		
10	4.04	2,02	100	1,90	22,4	12,5	79	12,1	2,3		28		-1,0				—				—			
15	4.08	2,02	102	2,04	21,9	12,5	75	12,6	—				—				—				—			
20	3,31	2,02	64	2,01	19,6	12,5	57	12,1	—				—				—				—			
25	3,02	2,02	50	1,96	17,7	12,5	42	12,0	1,7				—				—				—			
30	2,95	2,02	47	1,87	18,6	12,5	49	11,2	1,7				-0,7				—				—			
35	3,05	2,02	51	2,00	18,8	12,5	50	11,4	1,8				-1,0				—				—			
40	2,89	2,02	43	1,90	19,1	12,5	53	12,1	1,6				-0,8				—				—			
45	3,03	2,02	50	1,96	18,6	12,5	50	12,3	1,8				-0,8				—				—			
50	2,95	2,02	47	1,93	18,7	12,5	50	12,1	1,8				—				—				—			
55	2,98	2,02	48	1,98	18,3	12,5	46	11,8	1,8				—				—				—			
60	2,55	2,02	26	1,95	18,5	12,5	48	11,4	—				—				—				—